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RESULTS OF TENSILE TESTS ON TYPE 304 AND 316 STAINLESS STEEL PLATE AND WELDED JOINTS

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ABSTRACT

Tensile tests on reference and irradiated Type 304 and 316 stainless steels were performed. Both the plate material and welded joints were tested in air at 400°C on sub-size test pieces. The Type 304 and 316 plate materials were produced by Creusot Loire Industrie, France, whereas Krupp Südwestfalen AG, Germany, only produced the Type 316.
Siemens/KWU (formerly Interatom) has supplied both the plate and welded material.

Irradiations were performed in the HFR at Petten in TRIO irradiation devices to nominal damage levels up to 10 dpa at 400°C.
The reference materials were also heat treated at 400°C for 7,000 and 14,000 hours. These annealing times correspond with the time necessary to accumulate the 5 and 10 dpa damage levels respectively.

No significant influence of the annealing of the plate material was found on the yield strength and the UTS, whereas the ductility of the Type 304 reduces with increasing annealing time. The differences between the Type 304 and Types 316 were very small.
Between 1 and 4 dpa a strong increase was observed of the 0.2% yield strength values of the plate material. The ductility decreased sharply after high levels of irradiation.

CONTENTS

1. INTRODUCTION

As part of the Advanced Reactor Technology Research Programme the mechanical properties of reference and irradiated plate and welded material were determined. The materials investigated were Type 304 and 316 stainless steels, produced by Creusot Loire Industrie, France and Krupp Südwestfalen AG, Germany, and supplied by Siemens/KWU (formerly Interatom). The German material was designated as Type 316L (N) and for this purpose noted as Type 316K. The French materials were designated as Type 304L(N) and Type 316L(SPH), and noted as Type 304CL and Type 316CL.
The welded joints were made by Steinmüller on behalf of Siemens/KWU using the submerged arc welding (SAW) technique (on Type 304) and the manual arc welding (MAW) method (on Type 316).

Test pieces were taken at different locations of the plates and welded joints. The welded test pieces were taken perpendicular to the weld at different locations of the welded joints.
Flat and cylindrical sub-size test samples were used for the tensile tests at 400. The tests were performed at a constant strain rate of $3.10^{-4}.s^{-1}$ in air environment. The plate material was heat treated at 400 °C for 7,000 and 14,000 hours.

The objective of the tests were to quantify the influence of annealing time and irradiation on the mechanical properties of the materials.

This report presents the results of these tensile tests.

2. MATERIAL SPECIFICATION

2.1 Parent Material

The materials were produced by Creusot Loire Industrie, France and Krupp Südwestfalen AG, Germany, and supplied by Siemens/KWU.
Creusot Loire manufactured stainless steel Type 304L(N) with heat number 11080 and stainless steel Type 316L SPH with heat number 11477. The dimensions of the plates as delivered were 1000x1000x40 mm. Siemens/KWU supplied these materials with dimensions of 600x200x40 mm, 2 each.
The Krupp material was stainless steel Type 316L(N) with heat number 013824 with original dimensions of 1000x1000x30 mm. This material was supplied with a dimension of 700x170x30 mm.

The plates were coded SY IA537, subdivided in IA Code 46G1 and IA Code 46G1.1, GY IA522-17-13-2-IA Code 8TH1.2-StA 9/9, and SY IA540-IA Code 5*H14 respectively. From these plates various blocks were cut from which the test pieces were machined. This is indicated in Table 1.

In Table 2 the nominal chemical compositions are given.

2.2 Welding

The welded joints were made by Steinmüller on behalf of Siemens/KWU using the SAW and MAW welding techniques. U-shaped joints were involved.
The 40 mm thick plates were welded in 22 steps with electrode type 62.35.
The 30 mm thick plates were welded in 18 steps with two types of electrodes namely the Böhler 16-8-M and the type 17-13-2 electrode.
Both the welding as well as the X-ray procedures, and the quality control information are documented and reported as private communication.
The chemical composition of the filler material is given in Table 2a.

2.3 Test Pieces

The plates were cut into smaller parts according to a cutting scheme.
From these respective parts blocks were cut to machine the two types of test pieces.
The flat test pieces were machined from blocks with dimensions of
55x5 mm, with widths varying from 14 to 19 mm, depending on the cutting scheme.
The round test pieces were machined from blocks with dimensions of 50x19x11 mm. A schematic of the cutting scheme is given in Figure 1.
The test pieces have dimensions according to Figures 2 and 3.

The welded test pieces were cut from the center of the weld oriented perpendicular to the weld as well as devided over the thickness of the weldment. An example is given in Figure 4.

3. EXPERIMENTATION

3.1 Annealing

A number of test pieces, both parent material and welded joints, were heat treated at 400°C in air during 7,000 and 14,000 hours respectively. These times correspond to the irradiation period to achieve the nominal damage levels of 5 and 10 dpa respectively.

3.2 Neutron Irradiation

The irradiation experiments were performed in Trio capsules (R139–55–1 to 3, R139–57–1 and 2, and R275–1 and 2). The samples were loaded in different sample holders and irradiated at 400°C. The objective of the irradiation was to achieve a nominal displacement damage of 0.5, 1.0, 5, and 10 dpa.

The actual displacement damages found was for:

0.5	dpa:	0.280	to	0.533	dpa;
1.0	dpa:	0.600	to	1.24	dpa;
5	dpa:	3.3	to	4.5	dpa;
10	dpa:	7.9	to	10.6	dpa.

A detailed description of the irradiation experiments is given in [1–5].

3.3 Testing Method

The tests on the **flat specimens** were performed on a servo–hydraulic testing system, consisting of a plain bearing actuator with a dynamic force of about 25 kN. The tests were done under position control.

The strain rate was calculated based on the effective gaugelength of the test pieces.

Load–displacement curves were recorded on an analogue recorder.

The heating device consists of a two zone lamp furnace and controlled with two PID self tuning temperature controllers. The temperature can be held to within ± 5°C up to 550°C and about ± 10°C in the range of 550–800°C. Calibrated type K thermocouples were used to measure the temperature, which is recorded in an analogue way.

The tests on the **cylindrical specimens** were performed on the INSTRON 1362 electro–mechanical testing system with a frame capacity of 100 kN.

For these tests a loadcell with a capacity of 20 kN was used.

A resistance split furnace was used to obtain the testing temperature of which the stability is better than ± 5°C.

All tensile tests were performed in air at a constant strain rate of $3.10^{-4}.s^{-1}$.

From the load–displacement curves both the strengths as well as the elongations were determined graphically.

The elongation of the reference materials were measured after fracture on the test pieces.
The total elongation values of the irradiated test pieces were determined graphically as well as from photographs taken from the test pieces after fracture. The calculation of the total elongation of the flat specimens is based on a gauge length of 22 mm, whereas the gauge length of the cylindrical specimens is 23.5 mm.

4. RESULTS and DISCUSSION

The results are presented in Tables 3 to 14 and Figures 5 to 10.
Tensile tests were performed on reference and irradiated stainless steel Type 304 and 316 at 400 and 600°C, both parent material as well as welded joints.

a. Influence of annealing (Figures 5 and 6)

No significant influence of the annealing time was found on both the $\sigma_{0.2}$ and UTS values. From the materials it seemed that Type 304 showed better 0.2 yield stress values. A slight increase in UTS was found after the longest annealing time. With respect to the total elongation the Type 304 showed a significant reduction after 14,000 hours annealing at 400°C.

b. Comparison of Types 316 (Figures 5 and 6)

No differences were found in the 0.2 yield stress values and UTS between the two Type 316 materials both after the heat treatments as well as after irradiation. The total elongation values of Type 316 CL seems to be slightly higher, although a small number of tests were executed (see also Tables 7, 8, and 11, 12).
A same tendency was found for the welded material (Tables 9, 10 and 13, 14).

c. Influence of irradiation (Figures 7 and 8)

All $\sigma_{0.2}$ values of Type 304 plate are compared to the values of all Type 316 plate materials. The Type 304 and Type 316 materials showed identical trends of strong increase of the $\sigma_{0.2}$ values. At 4 dpa higher values were found for the Type 304 material. Type 304 seems to saturate already at 4 dpa, whereas the Type 316 materials seem to saturate at higher irradiation levels.
The total elongation values of all tests on Type 304 and 316 plate materials are given in Figure 8.
In general, no large differences were observed between the Type 304 and Type 316 materials.

c. Comparison between irradiated plate and welded material (Figure 9 and 10)

The average values of $\sigma_{0.2}$ and UTS of all Type 304 and 316 materials are given in Figure 9 and 10. The figures show the total width of the scatterband together with the mean trend curve for all materials.
The $\sigma_{0.2}$ values of the unirradiated welded material were higher than for the plate material. At higher irradiation levels no difference was observed anymore.
The UTS values showed no difference for all conditions, both irradiated and reference material.

Work hardening is only observed for the plate material at low dose irradiation levels. Expressed as the ratio of UTS/0.2 yield strength the value at low dose irradiation is approximately 2.5 and decreases to 1 at the high levels.
At 4 and 10 dpa the $\sigma_{0.2}$ and UTS values coincide (see Tables 4, 6, 8, 10, 12 and 14).

5. CONCLUSIONS

1. No significant influence was found on the $\sigma_{0.2}$ and UTS after annealing at 7,000 and 14,000 hours at 400°C respectively for all plate materials. The total elongation of the Type 304 was slightly reduced after long annealing times.
2. The Type 304 and Type 316 materials showed identical trends of strong increase of the $\sigma_{0.2}$ values. At 4 dpa higher values were found for the Type 304 material. Type 304 saturates already at 4 dpa, whereas the Type 316 materials seem to saturate at higher irradiation levels.
3. A sharp decrease in ductility was observed at 4 dpa. No significant difference was found for the Type 304 and Type 316 materials.
4. Besides higher $\sigma_{0.2}$ and UTS values all welded materials behaved in the same way as the plate materials.
   The work hardening capacity was almost lost already at 4 dpa.

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TABLES

Table 1 *Overview of the various plate numbers and test pieces*

The following welded test pieces were produced:

Spec.no.	Plate no.	Part no.	Position to weld
V 01 - V 06	SY IA537	E – F	perpendicular, center weld
V 07 - V 18	SY IA537	G – H	perpendicular, divided over 40 mm thickness, 2x6 pcs
V 19 - V 26	GY IA522	N – O	perpendicular, divided over 30 mm thickness, 2x4 pcs
Z 01 - Z 12	SY IA540	T – U	perpendicular, center weld
Z 13 - Z 30	SY IA540	V – W	perpendicular, divided over 40 mm thickness, 3x6 pcs

The following parent material test pieces were produced.

Spec.no.	Plate no.	Part no.	Position to weld
V 27 - V 32	SY IA537	H	parent material, divided over 40 mm thickness, 1x6 pcs
V 33 - V 44	SY IA537	G	parent material, divided over 40 mm thickness, 2x6 pcs
V 45 - V 52	GY IA522	N	parent material, divided over 30 mm thickness, 2x4 pcs
V 53 - V 64	GY IA522	L	parent material, divided over 30 mm thickness, 3x4 pcs
V 65 - V 72	GY IA522	M	parent material, divided over 30 mm thickness, 2x4 pcs
VV 1 - VV 10	SY IA540	R	parent material, divided over 40 mm thickness, 2x5 pcs
VV 11 - VV 20	SY IA537	B	parent material, divided over 40 mm thickness, 2x5 pcs
VV 21 - VV 30	GY IA522	J	parent material, divided over 30 mm thickness, 2x5 pcs

Table 2 *Chemical Composition of the Materials in wt %*

Element	AISI 304 Creusot Loire	AISI 316 Creusot Loire	AISI 316 Krupp
C	0.024	0.02	0.026
Ni	9.95	12.5	12.5
Cr	18.64	17.34	17.39
Mn	1.71	1.8	2.06
Cu	0.165	0.12	0.04
Si	0.327	0.32	0.15
S	0.001	0.0006	0.002
P	0.026	0.020	0.024
N	0.08	0.0696	0.0670
Co	0.058	0.03	0.05
B	0.001	0.0014	0.0004
Ti	<0.05	0.008	0.01
Nb	–	0.042	0.01
Mo	–	2.4	2.43
Ta	–	0.005	0.002
Fe	balance	balance	balance

Table 2a *Chemical Composition of the Weld Filler Materials in wt %*

Ref Material	AISI 304 Creusot Loire	AISI 316 Creusot Loire	AISI 316 Krupp
Filler Material	AISI 308L	17–13–2	16–8–M
Element			
C	0.018	0.047	0.041
Ni	10.04	11.77	9.36
Cr	19.51	18.38	16.62
Mn	1.35	1.58	1.11
Cu	0.11	0.06	0.06
Si	0.59	0.55	0.24
S	0.006	0.008	0.012
P	0.027	0.020	0.018
N	0.062	0.039	0.031
Co	0.06	0.06	0.03
B	<0.0002	<0.0002	<0.0002
Ti	<0.01	<0.01	<0.01
Nb	0.008	0.002	<0.002
Mo	0.11	2.21	1.74
Ta	<0.005	<0.005	<0.005
Fe	balance	balance	balance

Table 3 *Results of Tensile Tests on Type 304 Parent Material at 400 °C on Flat and Cylindrical Test Pieces*

Condition	Spec.No	$\sigma_{0.2}$ N/mm²	$\sigma_{0.5}$ N/mm²	σ_1 N/mm²	σ_5 N/mm²	UTS N/mm²	ε_u %	ε_t %
as received	V 27	236	250	263	326	416	24.6	27
	V 33	219	230	244	296	406	27.3	28.3
	V 34	193	206	226	295	410	28.7	32
7,000 hrs–400°C	V 38	238	247	255	296	351	20.4	22.8
	V 39	192	206	220	291	384	23	26
14,000 hrs–400°C	V 31	170	183	200	276	383	15.8	17
	V 32	203	216	223	303	390	18.3	19.1
as received	VV 12**	179	197	216	291	443	30.9	43.2
	VV 19**	176	193	212	286	440	30	42.1

** cylindrical specimens

Table 4 *Results of Tensile Tests on Irradiated Type 304 Parent Material at 400°C on Flat and Cylindrical Test Pieces*

Condition Irradiated	Spec.No	$\sigma_{0.2}$ N/mm^2	$\sigma_{0.5}$ N/mm^2	σ_1 N/mm^2	σ_5 N/mm^2	UTS N/mm^2	ε_u %	ε_t %
R275-1, 0.4 dpa	VV 13**	194	208	227	306	440	25.5	33.9
	VV 15**	195	207	222	304	454	30.3	42.7
	VV 17**	193	206	220	303	440	27.7	36.6
	VV 20**	191	204	219	300	444	27.6	36.4
R275-2, 0.8 dpa	VV 14**	197	211	231	313	434	23.9	33.6
	VV 16**	193	213	228	310	444	27.1	36.4
	VV 18**	204	216	233	314	444	28	35.2
T57-2, 4 dpa	V 41	566	566	563	-	573	0.8	5.3
	V 42	563	559	553	-	566	0.2	4.7
	V 43	616	616	599	-	623	0.2	5.1
	V 44	599	599	589	-	599	0.5	5.5
T55-1, 10 dpa	V 28	619	619	609	-	619	0.2	5.3
	V 29	606	599	586	-	606	0.2	4.5
	V 30	623	613	596	-	623	0.2	4.5
	V 37	619	603	596	-	623	0.2	4.7
T55-2, 10 dpa	V 35	609	603	593	-	616	0.4	4.6
	V 36	599	589	576	-	599	0.2	4.4

** cylindrical test pieces

Table 5 *Results of Tensile Tests on Type 304 Welded Material at 400°C*

Condition	Spec.No	$\sigma_{0.2}$ N/mm^2	$\sigma_{0.5}$ N/mm^2	σ_1 N/mm^2	σ_5 N/mm^2	UTS N/mm^2	ε_u %	ε_t %
as received	V 06	290	300	313	363	393	12.7	15
	V 15	273	293	306	360	366	8	9.4
	V 16	341	376	391	-	405	6	6.6
14,000 hrs–400°C	V 03	336	353	373	410	413	6.4	7.9
	V 04	283	300	313	370	400	12.8	13.8
	V 07	250	263	280	336	400	18.2	19.1
	V 09	286	303	316	376	403	16.7	18
	V 10	343	366	383	426	436	10.3	13.1
	V 11	293	313	326	380	400	11.3	13.9
	V 13	226	250	270	326	373	15.5	18.3
	V 17	293	306	323	370	393	12.9	14.4

Table 6 *Results of Tensile Tests on Irradiated Type 304 Welded Material at 400°C*

Condition Irradiated	Spec.No	$\sigma_{0.2}$ N/mm^2	$\sigma_{0.5}$ N/mm^2	σ_1 N/mm^2	σ_5 N/mm^2	UTS N/mm^2	ε_u %	ε_t %
T55–1, 10 dpa	V 01	619	611	549	-	619	0.2	4.8
	V 02	596	566	533	-	596	0.2	4.8
	V 08	583	576	589	-	589	0.2	4.6
	V 14	586	583	586	-	586	0.2	4.4
T55–2, 10 dpa	V 12	599	593	-	-	599	0.2	4.0
	V 18	583	583	-	-	583	0.2	3.4

Table 7 *Results of Tensile Tests on Type 316 K(rupp) Parent Material at 400°C on Flat and Cylindrical Test Pieces*

Condition	Spec.No	$\sigma_{0.2}$ N/mm^2	$\sigma_{0.5}$ N/mm^2	σ_1 N/mm^2	σ_5 N/mm^2	UTS N/mm^2	ε_u %	ε_t %
as received	V 61	173	187	200	266	413	29.5	32
7,000 hrs-400°C	V 60	158	173	185	246	397	24.6	30.8
14,000 hrs-400°C	V 45	156	167	177	241	407	30.1	31.9
	V 48	169	179	192	253	400	29.1	32.4
	V 71	169	180	188	248	399	30.2	32
as received	V22**	165	189	203	271	451	34.2	45.2
	V29**	171	194	209	276	450	32.1	44.2

** cylindrical test pieces

Table 8 *Results of Tensile Tests on Irradiated Type 316 K(rupp) Parent Material at 400 °C on Flat and Cylindrical Test Pieces*

Condition Irradiated	Spec.No	$\sigma_{0.2}$ N/mm^2	$\sigma_{0.5}$ N/mm^2	σ_1 N/mm^2	σ_5 N/mm^2	UTS N/mm^2	ε_u %	ε_t %
R275-1, 0.4 dpa	VV 23**	182	197	208	275	461	32.1	44.1
	VV 25**	177	192	203	271	461	32.4	43.8
	VV 27**	177	196	207	272	458	30.9	42.2
R275-2, 0.8 dpa	VV 24**	189	202	215	286	453	28.5	38
	VV 26**	190	205	218	286	462	30.1	41.2
	VV 28**	200	205	224	291	459	31.2	42
	VV 30**	201	216	230	301	461	30	40.6
T57-1, 4 dpa	V 52	426	440	450	480	486	9	12.8
	V 55	393	410	423	466	483	11.6	15.4
	V 56	423	436	446	480	493	10	14.2
	V 57	480	486	496	519	523	6.6	10.6
T55-2, 10 dpa	V 67	593	596	596	-	596	1.5	5.9
	V 68	573	583	586	-	583	2.1	6.2
T55-3, 10 dpa	V 46	589	591	589	-	591	0.6	4.8
	V 47	599	606	603	-	606	1.1	5.3
	V 50	594	599	598	-	599	1	4.7
	V 51	586	593	593	-	593	1	4.7

** cylindrical specimens

Table 9 *Results of Tensile Tests on Type 316 K(rupp) Welded Material at 400°C*

Condition	Spec.No	$\sigma_{0.2}$ N/mm²	$\sigma_{0.5}$ N/mm²	σ_1 N/mm²	σ_5 N/mm²	UTS N/mm²	ε_u %	ε_t %
as received	V 26	296	310	323	380	433	18	19.5

Table 10 *Results of Tensile Tests on Irradiated Type 316 K(rupp) Welded Material at 400°C*

Condition Irradiated	Spec.No	$\sigma_{0.2}$ N/mm²	$\sigma_{0.5}$ N/mm²	σ_1 N/mm²	σ_5 N/mm²	UTS N/mm²	ε_u %	ε_t %
T57-1, 4 dpa	V 23	466	483	496	-	513	3.5	6.8
	V 24	516	533	543	-	549	2.1	5.7
T55-3, 10 dpa	V 19	596	598	593	-	598	0.5	4.7
	V 20	609	613	606	-	613	0.5	4.9
	V 21	611	616	613	-	616	0.5	5.3
	V 22	599	599	596	-	599	0.5	4.7

Table 11 *Results of Tensile Tests on Type 316 C(reusot) L(oire) Parent Material at 400°C*

Condition	Spec.No	$\sigma_{0.2}$ N/mm^2	$\sigma_{0.5}$ N/mm^2	σ_1 N/mm^2	σ_5 N/mm^2	UTS N/mm^2	ε_u %	ε_t %
as received	VV 3**	164	179	195	266	455	31.6	44.7
	VV 4**	163	181	195	265	456	33.4	44.4
7,000 hrs-400°C	Z 50	154	167	180	247	407	31.5	34
	Z 51	152	166	178	244	411	33.5	36

Table 12 *Results of Tensile Tests on Irradiated Type 316 C(reusot) L(oire) Parent Material at 400°C*

Condition Irradiated	Spec.No	$\sigma_{0.2}$ N/mm^2	$\sigma_{0.5}$ N/mm^2	σ_1 N/mm^2	σ_5 N/mm^2	UTS N/mm^2	ε_u %	ε_t %
R275-1, 0.4 dpa	VV 5**	162	173	189	255	461	34.3	45
	VV 7**	157	168	181	249	461	34.4	45.8
R275-2, 0.8 dpa	VV 6**	172	182	195	263	462	33.7	44.2
	VV 8**	161	171	183	254	456	33.5	44.2
T57-2, 4 dpa	Z 53	519	533	543	549	549	5.5	9.7
	Z 54	500	513	519	526	526	5	9.3

Table 13 *Results of Tensile Tests on Type 316 C(reusot) L(oire) Welded Material at 400°C*

Condition	Spec.No	$\sigma_{0.2}$ N/mm²	$\sigma_{0.5}$ N/mm²	σ_{1} N/mm²	σ_{5} N/mm²	UTS N/mm²	ε_u %	ε_t %
7,000 hrs–400°C	Z 01	306	329	349	417	451	12.3	14.4
	Z 02	308	326	347	407	451	15.5	17.6
	Z 12	313	333	356	420	460	16	18.3

Table 14 *Results of Tensile Tests on Irradiated Type 316 C(reusot) L(oire) Welded Material at 400°C*

Condition	Spec.No	$\sigma_{0.2}$ N/mm²	$\sigma_{0.5}$ N/mm²	σ_{1} N/mm²	σ_{5} N/mm²	UTS N/mm²	ε_u %	ε_t %
T57–2, 4 dpa	Z 18	512	530	536	-	540	1.7	5
	Z 22	543	559	559	-	566	0.7	4.2

FIGURES

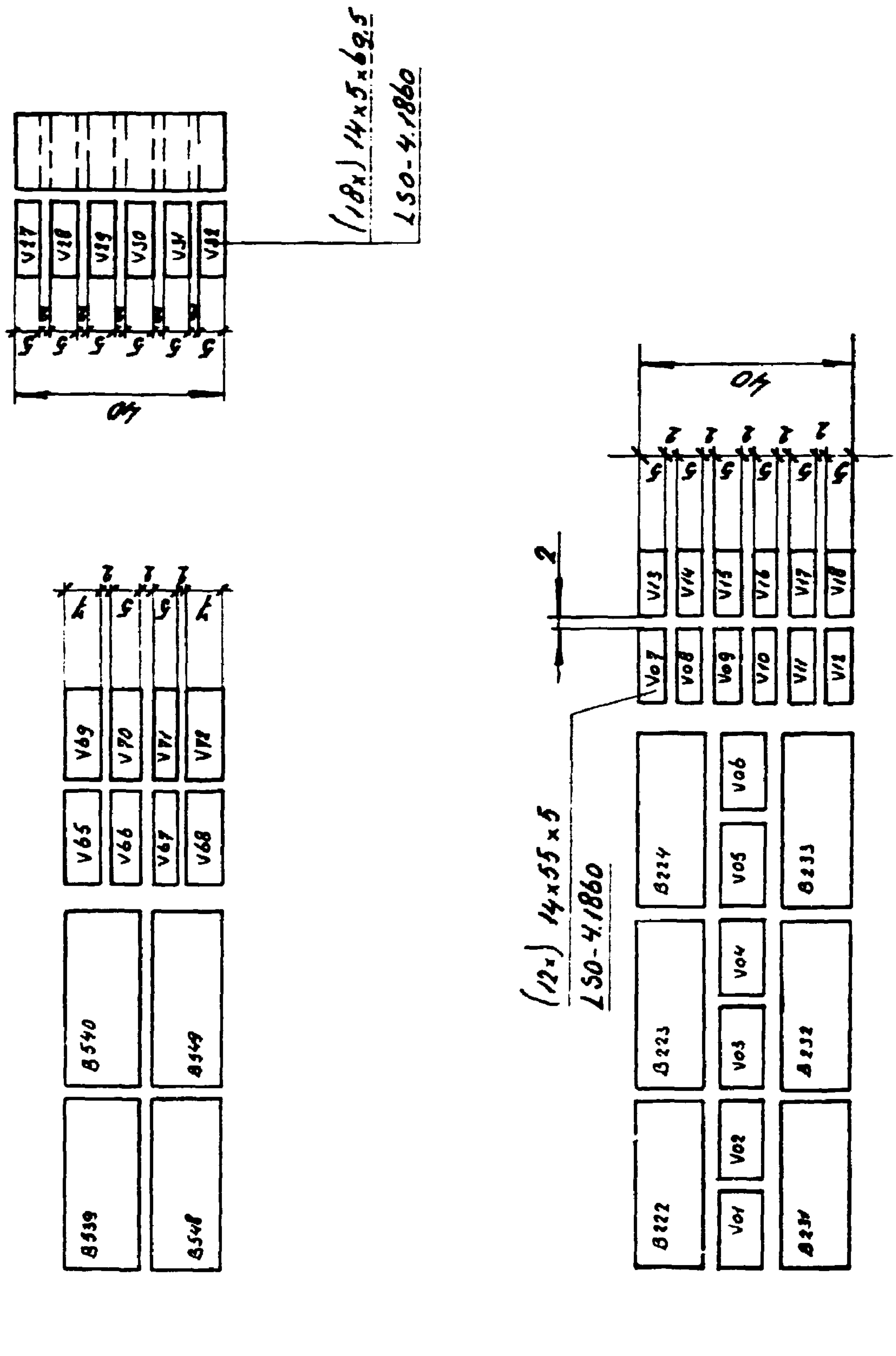


Figure 1 *Schematic of cutting scheme*

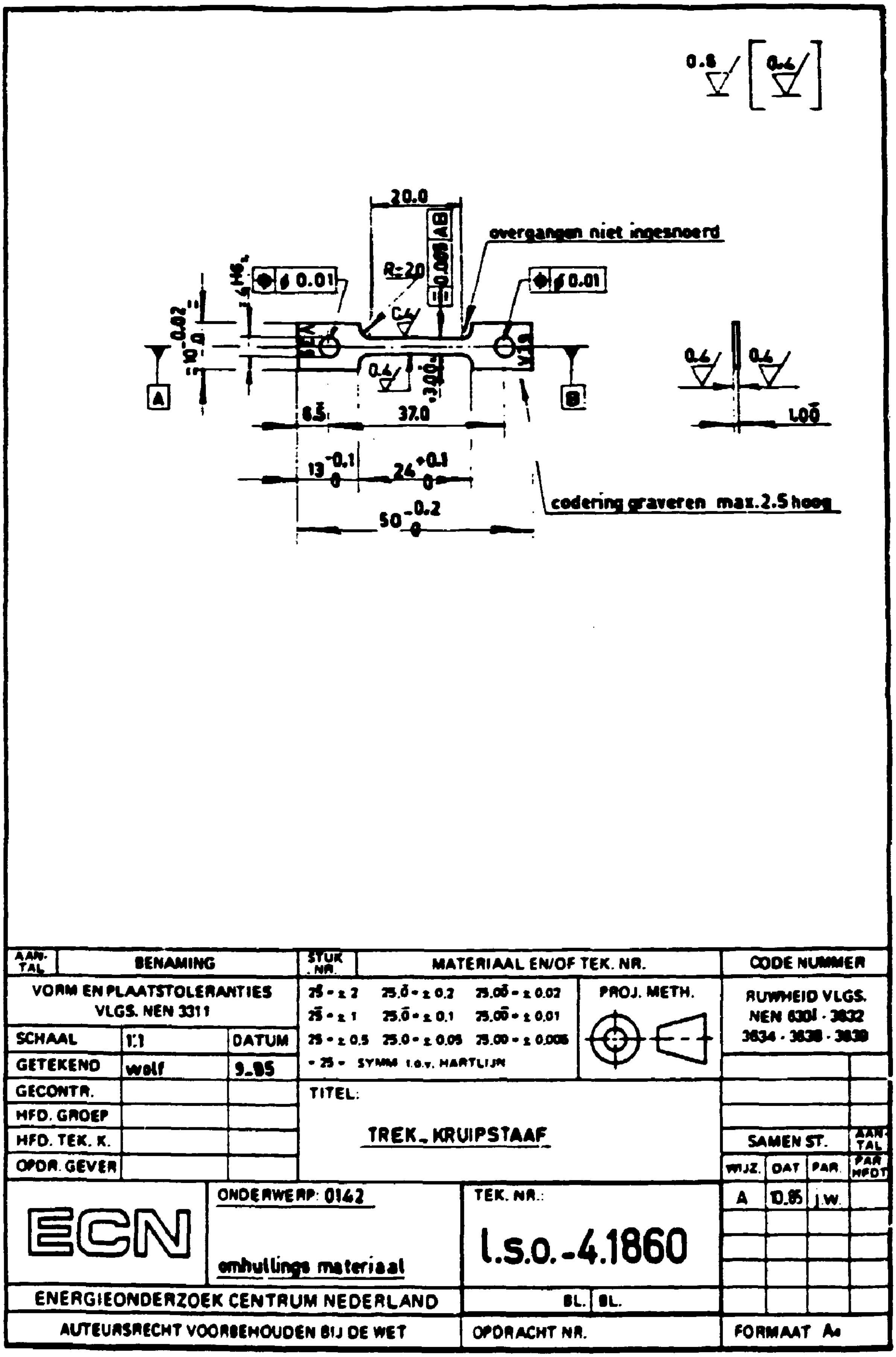
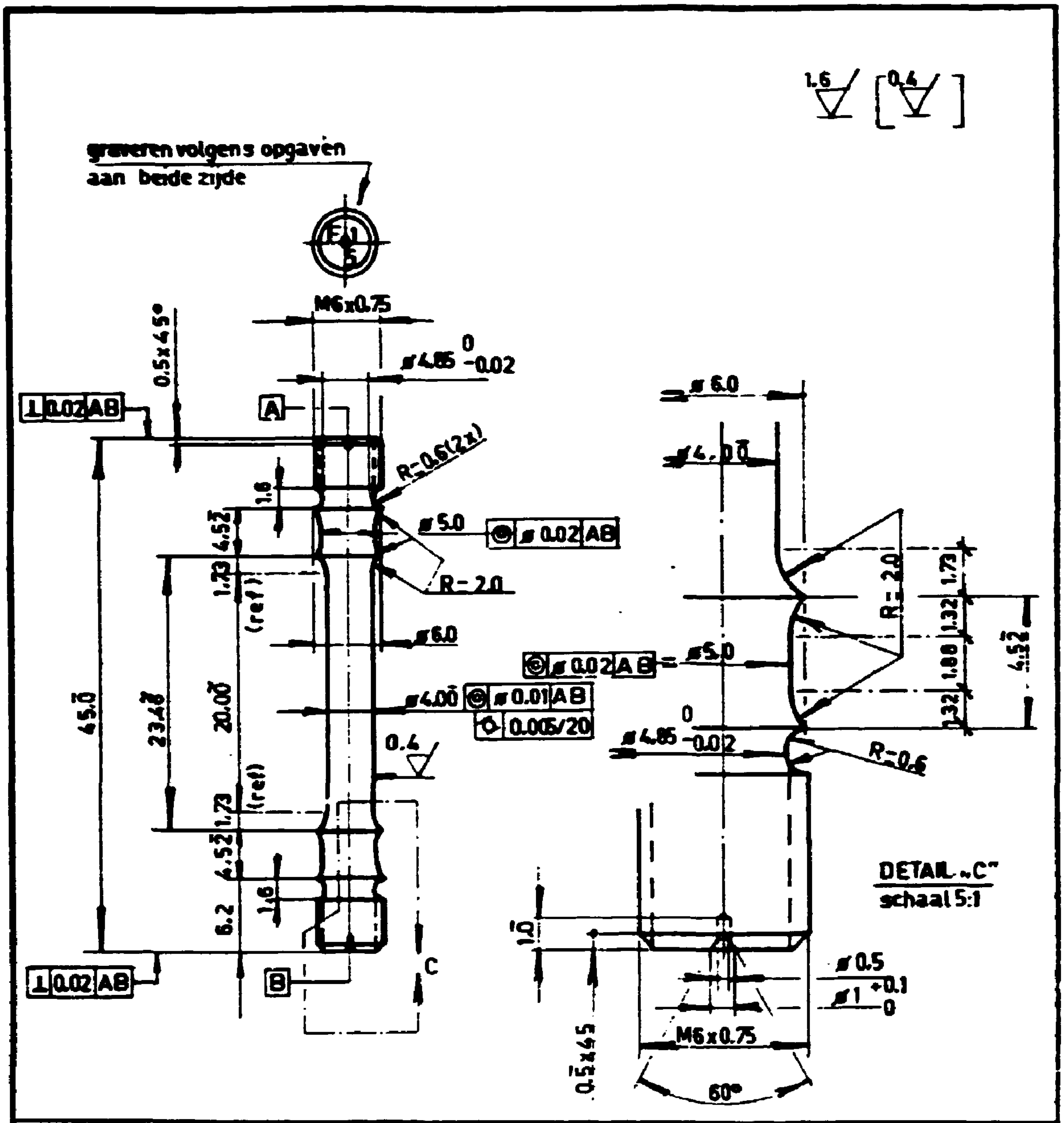


Figure 2 *Dimensions of flat test pieces*



AAN-TAL	BENAMING	STUK NR.	MATERIAAL EN/OF TEK. NR.	CODE NUMMER

VORM EN PLAATSTOLERANTIES VLGS. NEN 3311		25 = ± 2 / 25 = ± 1 / 25 = ± 0,5	25,0 = ± 0,2 / 25,0 = ± 0,1 / 25,0 = ± 0,05	25,00 = ± 0,02 / 25,00 = ± 0,01 / 25,00 = ± 0,005
SCHAAL	2:1	DATUM	• 25 • · SYMM. t.o.v. HARTLIJN	
GETEKEND	j.w.	10_85		
GECONTR.			TITEL:	
HFD. GROEP			PROEFSTAAF	
HFD. TEK. K.				
OPDR. GEVER				

PROJ. METH.

RUWHEID VLGS. NEN 6301 · 3632 3634 · 3638 · 3639

SAMEN ST. | AAN TAL

WIJZ. | DAT | PAR | PAR HFDT

ECN	ONDERWERP: 0142 bg.1424	TEK. NR.: l.s.o.-4.1866
ENERGIEONDERZOEK CENTRUM NEDERLAND		BL. | BL.
AUTEURSRECHT VOORBEHOUDEN BIJ DE WET		OPDRACHT NR.

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Figure 3 *Dimensions of cylindrical test pieces*

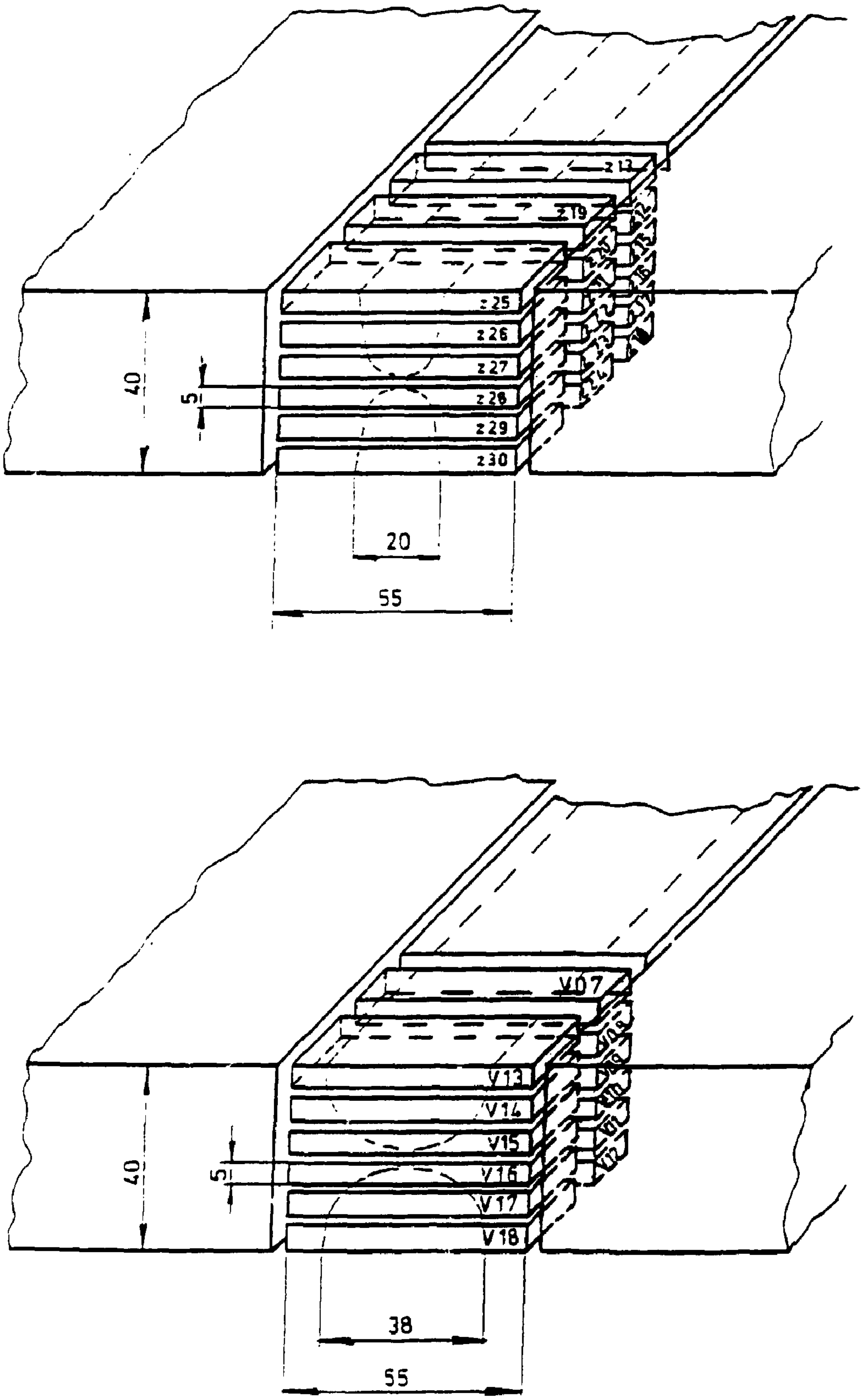

Figure 4 *Example of cutting scheme for welded test pieces*

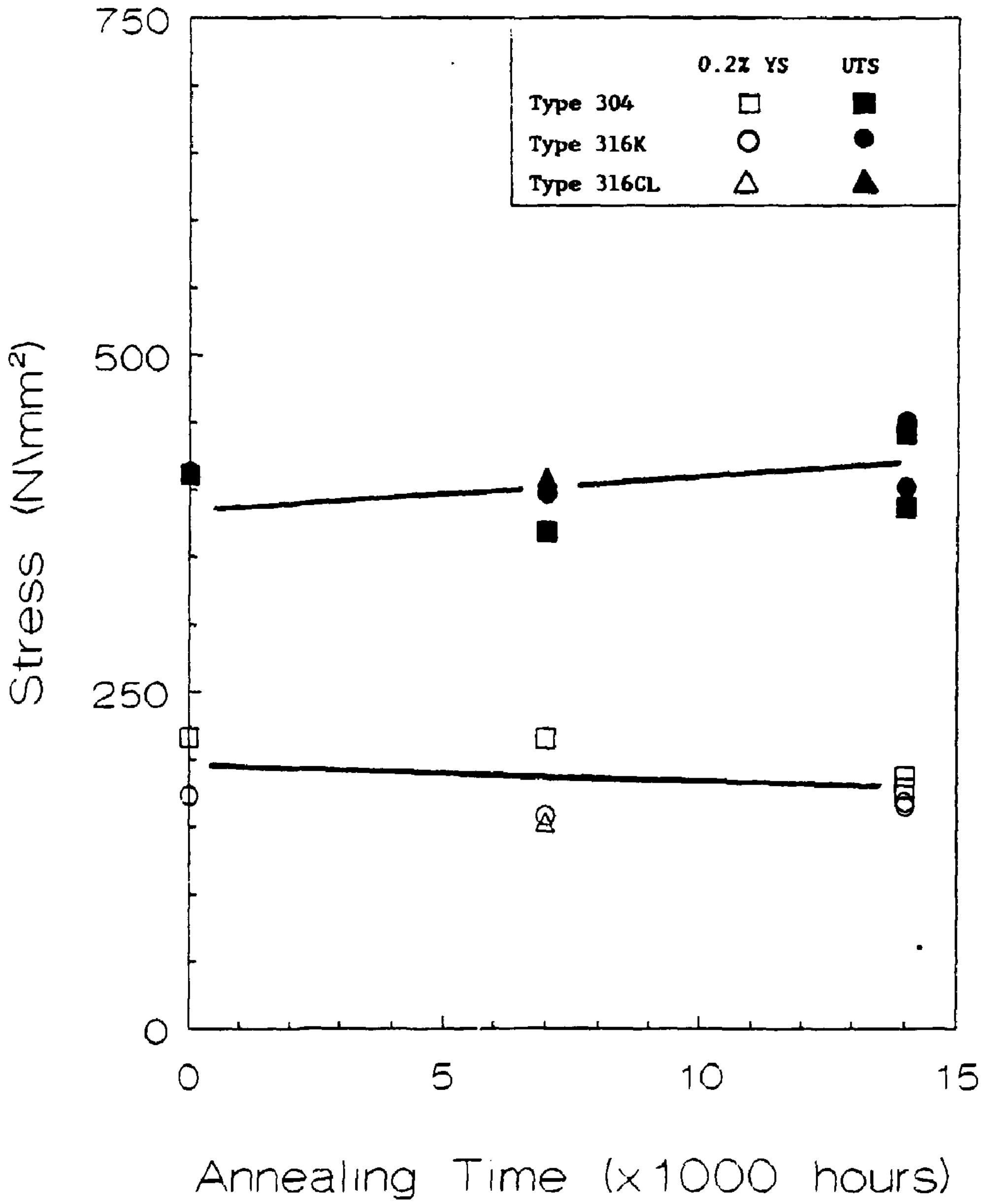

Figure 5 *Influence of Annealing Time on $\sigma_{0.2}$ and UTS of Type 304 and 316 Plate Material*

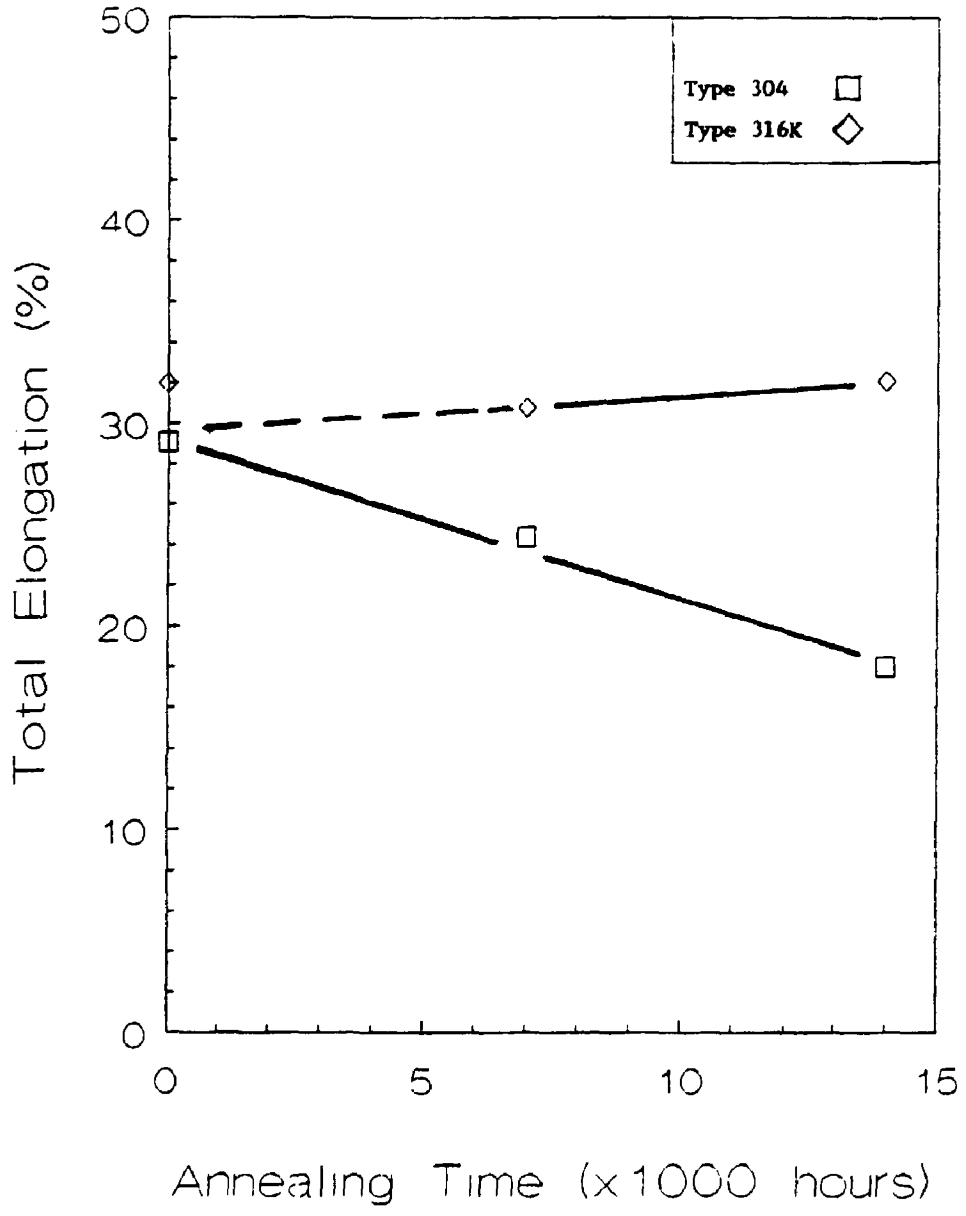

Figure 6 *Influence of Annealing Time on Total Elongation of Type 304 and 315 Plate Material*

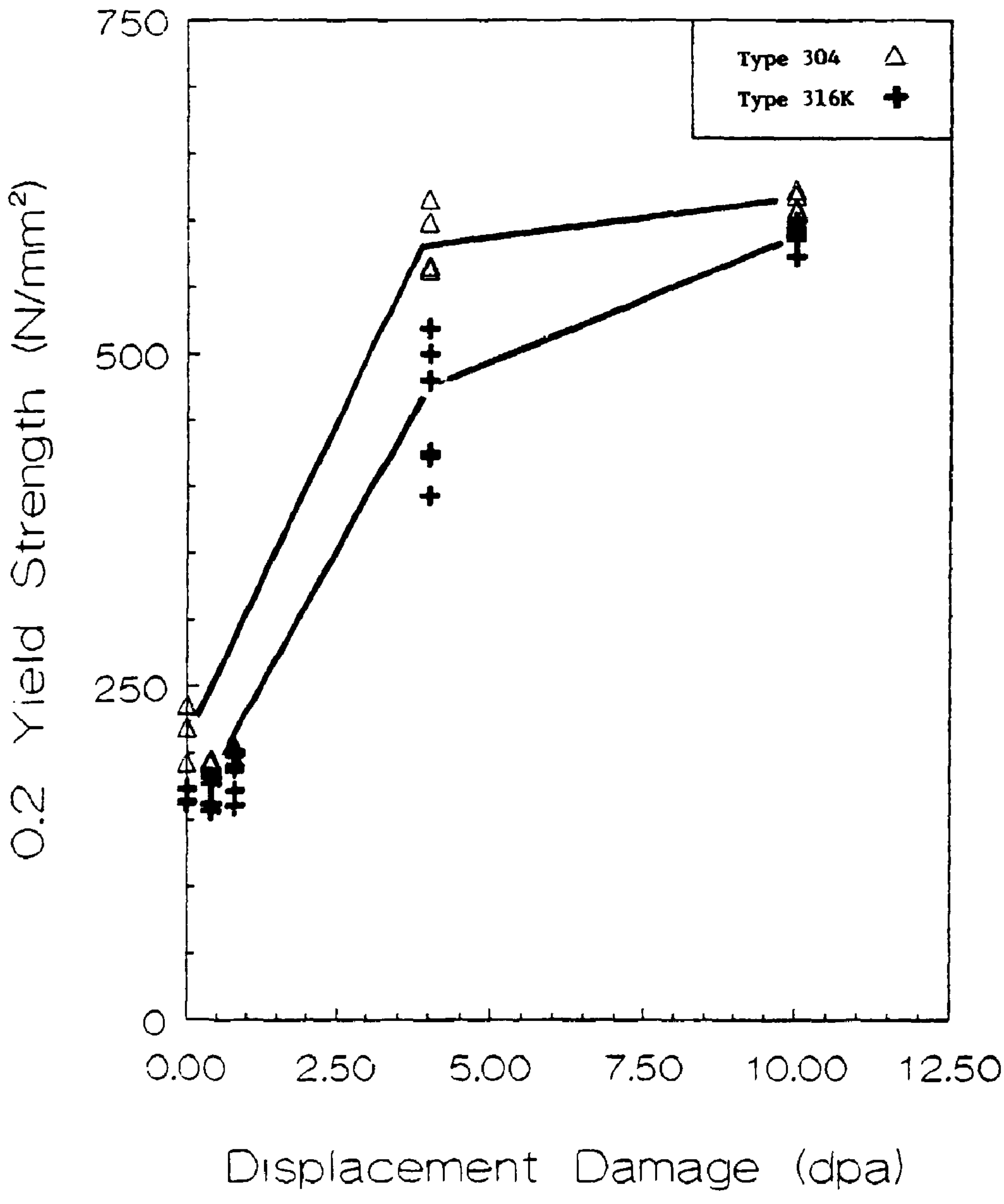

Figure 7 *$\sigma_{0.2}$ values of Type 304 and 316 Plate Material*

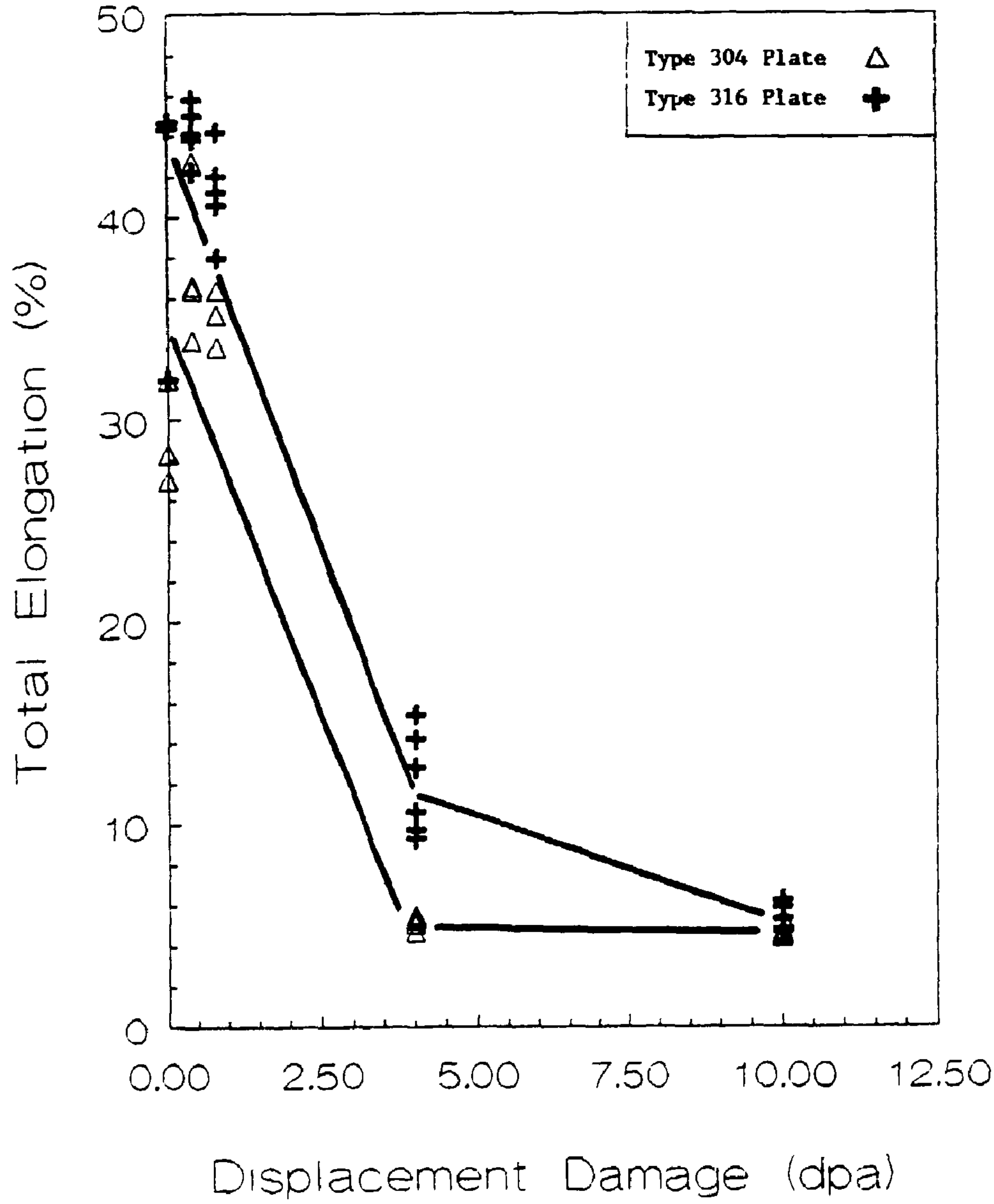

Figure 8 *Total Elongation values of Type 403 and 316 Plate Material*

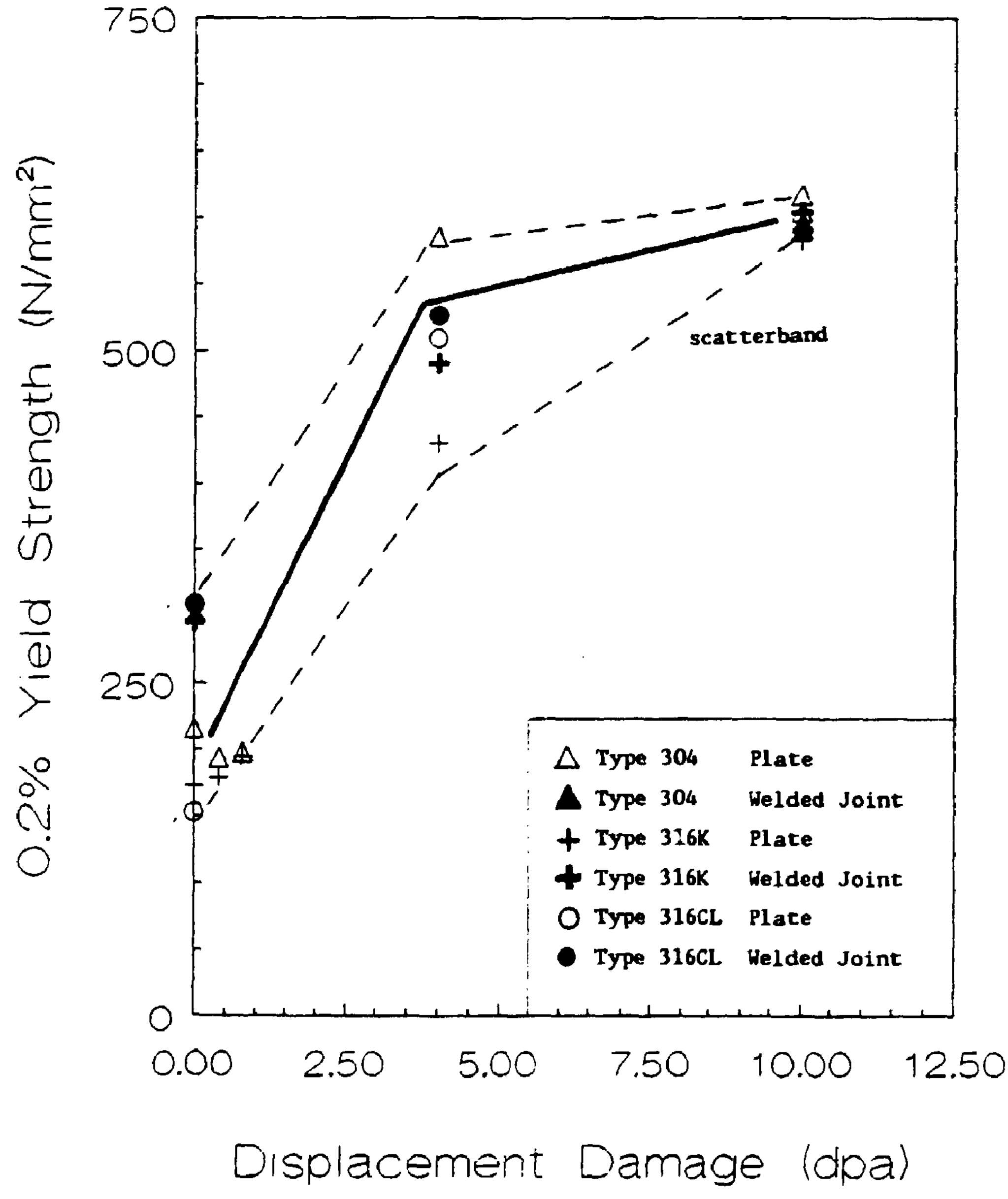

Figure 9 *Trend curve on irradiation hardening of Type 304 and 316 Plate and Welded Material at 400°C*

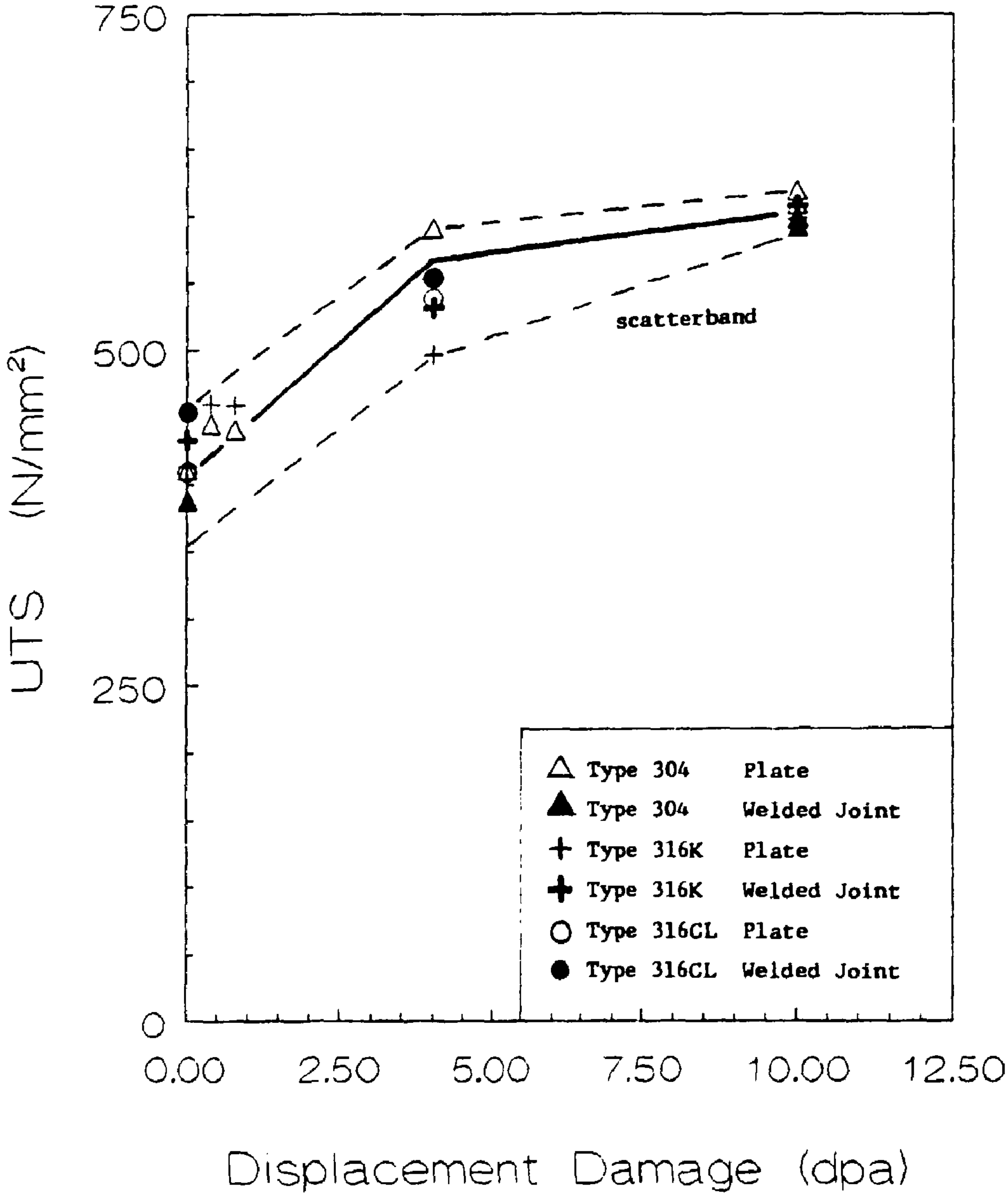

Figure 10 *Trend curve for hardening effect on the UTS values of Type 304 and 316 Plate and Welded Material at 400°C*