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Influence of pretreatment, environment and strain rate on stress corrosion cracking of the aluminium alloy 7075-T6

Report LR-433
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CONTENTS

ABSTRACT

The influence of some testing environments and strain rates on the initiation of stress corrosion cracks in the aluminium alloy 7075-T6 is investigated. Also the influence of some different pretreatments on the SCC behaviour of this alloy is studied, including the pretreatment according to the German standard for stress corrosion testing LN 65666.

It is shown that the latter pretreatment results in a surface attack of the material, which might influence the SCC results. Addition of chromate ions to the LN 65666 environment eliminates the general corrosion of the material, but has the disadvantage that the stress corrosion time is drastically increased.

Addition of hydrogenperoxide, or the use of symthetic seawater decreases the time-to-failure as compared to a 3 wt perc. NaCℓ-environment.

A decrease of the strain rate produced a more distinct SCC behaviour in all environments.

1. INTRODUCTION

Aluminium alloys of the 7000-series (Aℓ-Zn-Mg) are known to be very susceptible to SCC when they are aged to peak-hardness (T6-condition), especially in environments containing chloride-ions. In the literature much attention is paid to the investigation of the SCC-properties of these, and other types of aluminium alloys in environments containing chloride-ions. However, there is no generally accepted standard for SCC testing procedures. So a wide variety of specimen types and environments is used in these investigations. A comparison of reported results is therefore often very difficult.

In 1981 the EAA Working Group on Slow Strain Rate Stress Corrosion Testing of Aluminium Alloys initiated a Round Robin Programme to evaluate the constant strain rate technique for aluminium alloys [1]. In this programme four test environments were selected:

1. Inert (dry air, dry nitrogen or vacuum)
2. 2 % NaCℓ + 0.5 % Na_2CrO_4, pH3.0 (according to the German specification LN 65666)
3. 3 % NaCℓ + 0.3 % H_2O_2
4. 3 % NaCℓ

Some of the collaborating laboratories added some other environments, such as seawater and tap water.

The results of the Round Robin Programme were published in 1982 [2].

As far as the 7075-T651 alloy is concerned, the results are presented in Figure 1.

One of the results was that the test solution according to the German Standard LN 65666 with a pH-value of 3.0 was more aggressive than a 3 % NaCℓ-solution with free pH-value (pH-value probably between pH 6.5-8). This result is not consistent with the results of other investigators who found that in the LN 65666 environment not only the general corrosion was eliminated, but that also stress corrosion crack initiation and crack growth was almost completely stopped [3, 4, 5]. In these experiments however, the constant displacement and constant deformation method were adopted. It was also reported that an undesirable surface attack of the specimens occurred, caused by the pretreatment according to the LN 65666 standard [4].

Experience in our own laboratory with the LN 65666 environment was limited to constant strain rate tests [6]. So it was felt that it could be useful to investigate the influence of several environments, including the four used in the Round Robin Programme mentioned before, using both the constant deformation method as well as the constant strain rate method.
The experiments were carried out by the second author as a part of his masters thesis project.

2. EXPERIMENTAL PROCEDURES

2.1 Specimens

a) Constant deformation tests

The specimen type used for the constant deformation tests is the bent-beam specimen. The material is bare 7075-T6 sheet with a thickness of 1.5 mm, an ultimate tensile strength of 583.7 MPa and a yield strength of 526.8 MPa. Specimen dimensions are given in figure 2a. The specimens were clamped in a holder made of Trovidur plastic. The maximum tensile stress in the outer fibres of the specimen can be calculated with the formula given in Ref. [7]:

$$L = (KtE/\sigma \arcsin (H\sigma/KtE)$$

where L = specimen length
K = constant (1.280)
t = specimen thickness
E = modulus of elasticity
H = holder span
σ = maximum tensile stress.

Specimen length and holder span were chosen in such a way that the maximum stress was 350 MPa.

b) Constant strain rate tests

The specimens for the constant strain rate tests are made from a bare 7075-T6 plate with a thickness of 12.7 mm. The static mechanical properties of the specimens are: UTS = 578.6 MPa and YS = 521.3 MPa [8].
The specimens were loaded in the LT-direction. The dimensions of the specimen are given in figure 2b. The specimens have a gage-length of 7 mm with a reduced diameter to assure that failure will always occur in the specimen part that is enclosed by the corrosive environment.
Tests were carried out on three modified Monsanto tensometers. A description of the equipment is given in ref. [9].
A preload of 2000 N (corresponding to 102 MPa) is applied in all stress corrosion experiments, to eliminate the influence of clearance in the loading equipment (reduction gearbox, grips, etc.)
Four different strain rates are used, eq.
5.8×10^{-8} sec^{-1}, 2.9×10^{-7} sec^{-}, 1.45×10^{-6}, sec^{-1} and 7.25×10^{-6} sec^{-1}.
These strain rates are measured in the elastic part of the stress-strain curve.

2.2 Pretreatment and environment

Two different pretreatments are used: one in which the specimens are degreased according to our standard laboratory procedure (degreasing in an alkaline degreasing solution) and one according to the LN 65666 standard [10].

The standard laboratory pretreatment is:

- degreasing in a P_3 RST-solution, 10 min. at 60° C
- rinsing in destilled water
- drying with compressed air.

The pretreatment according to the LN 65666 standard is:

- degreasing in P_3 RST-solution, 10 min. at 60° C *)
- immersion in a HNO_3-solution (1:3, 32 %) for 1 hour at roomtemperature
- rinsing in destilled water
- pickling in a 10 % NaOH-solution, 1 min. at 60° C
- rinsing in destilled water
- removing of the pickling deposits in a HNO_3-solution (1:1, 32 %), 1 min. at R.T.
- rinsing in destilled water
- drying with compressed air or rinsing in alcohol.

*) according to LN 65666 degreasing should be done in C Cℓ4; because this is a rather harmful chemical that requires special precautions, we have substituted it by the harmless P_3RST-solution.

Eight different environments were selected:

A1. 2 % NaCℓ + 0.5 % Na_2CrO_4, pH3 (LN 65666)
A2. 2 % NaCℓ + 0.5 % $K_2Cr_2O_7$, pH3
A3. 3 % NaCℓ + 0.3 % H_2O_2 (20 %), pH3
A4. 3 % NaCℓ,pH3
A5. Substitute Ocean Water, pH3.

B/C5. 2 % NaCℓ + 0.5 % Na_2CrO_4, natural pH ∿ pH7-7.5
B/C4. 3 % NaCℓ, natural pH, pH ∿ 7 - 7.5
B/C5. Subst. Ocean Water, pH 8.2 (ASTM D1141-75) [11].

Pretreatment of the A and C series was according to LN 65666, the specimens in the B-series were only degreased in a P_3RST-solution.

Environment A1 is the standard LN 65666 solution. In A2 the Na_2CRO_4 is substituted by $K_2Cr_2O_7$, because it is sometimes reported that this chemical, although as effective as Na_2CrO_4 with respect to avoiding general corrosion, has less influence on the susceptibility to SCC.
The chemical composition of the substitute ocean water is according to ASTM D1141-75 without heavy metals. Pitting and general corrosion of aluminium alloys in substitute ocean water is claimed to be less than in a NaCℓ-solution. To allow a realistic comparison between the different solutions, the environments in the A-series are all adjusted to pH3. Although the chloride-ion concentration of the environments is not the same, it has been shown that the differences on the time-to-failure in SCC-experiments between a 2 % NaCℓ-solution and a 3 % NaCℓ-solution can be neglected [9].
The difference between the environments used in test series A and those used in series B and C is the pH-value. The only difference between test series B and C is the pretreatment. Originally also tests in environments B/C1 and B/C2 were planned, which environments comply with the A1 and A2 environments except for the pH-value. Based on the test results in the A1/A2 environments is was decided to cancel these tests, because it could be expected that in the less aggressive B/C1 and B/C2 environments no SCC would occur.
Constant strain rate tests are also performed in laboratory air to provide a reference for the SCC tests.

The solutions used in the constant deformation tests are kept at a temperature of 20 ± 1 ^{o} C and refreshed weekly. Temperature of the solutions used in the constant strain rate tests is kept at 25 ± 0.2 ^{o} C. Here the solution is circulated from a 10 liter reservoir through the environmental cell by a pump. pH-control measurements are performed every day, except in the weekends. If necessary the pH is adjusted by addition of dilute HCℓ or NaOH.
All the solutions are bubbled with air. A survey of the combinations of pretreatment, environment and test method is presented in table 1.

3. RESULTS

3.1 Constant deformation tests

In each environment 6 specimens are tested. Before immersion in the test solution all specimens are weighed to determine the weight loss caused by the pretreatment. The weight loss caused by the LN 65666 is about 0.69 wt. percent; the degreasing in the P_3RST-solution caused no measurable weight loss. Figure 3 shows the surface attack caused by the LN 65666 pretreatment. In figure 4,5 and 6 the surface of the specimens after the stress corrosion test is shown.

The surfaces of the specimens tested in the chromate-ion containing environments (A1 and A2) are completely free from corrosion products, even after 100 days of exposure. Addition of H_2O_2 increases the surface attack at all pH-values used. Substitute ocean water according to ASTM D1141 is very effective in reducing pitting (figure 8).

In table 2 the time-to-failure of all specimens is presented. After 100 days of exposure only 2 specimens in each of the chromate-ion containing environments have failed. After 100 days the tests were stopped, so no mean time-to-failure in these two environments is calculated. However, in some of these specimens a remarkable phenomenon has been observed. In some cases a crack is initiated at the small side of a specimen. This crack then propagates into the specimen and enters the surface of the specimen at the bottom side. So the crack growth takes place in the part of the specimen where a compression stress exists. A similar observation was made by Schra, who found cracking at the inner surface of horse shoe specimens in a Na_2CrO_4-environment [4]. The main time-to-failure in all environments is graphically presented in figure 7.

As can be expected the lifetime of the specimens in the environments with pH3 is shorter than in the corresponding environments with higher pH-values. The assumption that addition of K_2CrO_7 has less influence on the SCC-susceptibility is not true.

Although the mean time-to-failure of the two specimens that failed in the $K_2Cr_2O_7$-environment is shorter than that of the specimens failed in the Na_2CrO_4-environment, in both environments 4 specimens did not fail after 100 days exposure. The most aggressive environment is the substitute ocean water with pH3. Ranking of the A-series environments in order of decreasing aggressiveness is: A5/A3/A4//A1, A2.

The purpose of the testseries B and C is to study the influence of the pretreatment. In two of the three environments the lifetime of the specimens with the LN 65666 pretreatment is shorter than the lifetime of the specimens degreased in P_3RST only, although the difference in the 3 % NaCℓ : 0.3 % H_2O_2-solution is minimal. IN the substitute ocean water environment the lifetime of the specimens with the LN 65666 pretreatment is much larger than that of the specimens which are degreases only. A possible explanation of this unexpected behaviour can be that the experiments with the LN 65666 pretreatment are carried out several months later than the other experiments.
In all experiments the same stock solutions (see ref. 11) are used to make the substitute ocean water. As is pointed out by Rowland and Dexter it is possible that CO_2-gas has escaped from the stock solution, resulting in a longer lifetime of the specimens [12].

3.2 Constant strain rate tests

For each of the four different strain rates used in the SCC experiments, also tests in (laboratory) air are performed to provide a basis for comparison. In these tests in air also the influence of the strain rate and the pretreatment on the mechanical properties of the specimens is investigated. The results are presented in table 3. The values presented in this table are the mean values of 3 specimens for each strain rate and pretreatment.
Decreasing the strain rate seems to result in a small decrease in the strength properties and an increase of the elongation after fracture. There is also a small influence of the pretreatment. The strength properties of the specimens with the LN 65666 pretreatment are slightly lower than those without a pretreatment (except at the lowerst strain rate).

The results of the SCC tests are presented in tables 4 to 7. These values are the mean test results of, in most cases, two specimens. Only in the case the scatter in the results of two specimens is large, a third specimen is tested. Three criteria for the SCC-susceptibility are used: the stress at failure, the elongation after failure and the time-to-failure (figure 8). The three properties are made dimensionless by dividing the values by the corresponding values in air. From these tables it can be seen that the ranking of the environmints with respect to the aggressiveness depends on the failure criterion that is used. The failure stress criterion and the time-to-failure criterion both give a ranking which is depending on the strain rate. Only the elongation after fracture criterion results in almost the same ranking of the environments for all 4 strain rates. In order of decreasing aggressiveness the ranking of the A-series environments is: A5/A3/A4/A1. For the B-series environments the ranking for the two lowest strain rates is also the same: B2/B4/B5. For a strain rate of 1.45 x 10^{-6} $\sec^{-}$ the ranking is slightly different: B3/B5/B4.

One of the most important reasons to use the constant strain rate testing method is that it is a very rapid method to investigate the SCC-susceptibility of a material in a particular environment. There is of course a direct correlation between the strain rate and the testing time. Scamans [1] reported that a strain rate of 10^{-3} $\sec^{-1}$, resulting in testing times of only 2-3 minutes, was sufficient to achieve a satisfactory ranking of SCC-susceptibility of an Aℓ-5 % Mg alloy in a 3 % NaCℓ + 0.3 % H_2O_2 solution. However, this strain rate proved to be too fast to yield satisfactory results in a substitute ocean water or a LN 65666 environment [1]. In the Round Robin Programme of the EAA Working Group a strain rate of about 10^{-6} $\sec^{-1}$ is used [1, 2]. In our laboratory experiments with very fast strain rates (10^{-3} to 10^{-5} $\sec^{-1}$) were never successful. In figure 9 the influence of the strain rate on the SCC-results of the present experiments is shown.
It is obvious that there is a direct correlation between the aggressiveness of the environment and the maximum strain rate that can be used. Also the choice of the failure criterion plays an important role. In figure 10 the results obtained with a strain rate of 5.8 x 10^{-8} $\sec^{-1}$ are summarized. This strain rate is slow enough to give satisfactory results even in the LN 65666 environment.

4. DISCUSSION

The main reason of the addition of chromate-ions to a NaCℓ-solution used for stress corrosion experiments, according to the German standard LN 65666, is to avoid general corrosion and pitting of the specimens. In stress corrosion crack growth experiments the crack growth rate can be influenced by wedging due to corrosion products caused by general corrosion. On the other hand severe pitting can cause failure of a specimen before stress corrosion cracking can take place. The results of this investigation, and those of other investigators, show that although the addition of chromate-ions is very effective in avoiding general corrosion and pitting, it will also influence the susceptibility to stress corrosion cracking in an unacceptable manner. This is especially important if the SCC-behaviour of less susceptible materials has to be investigated. If the constant strain rate method is used in the experiments, the testing times are generally rather low. In this case general corrosion and pitting play a less important role, particularly when the environment is not too aggressive. A much better environment for stress corrosion testing proved to be the synthetic seawater or substitute ocean water, according to the ASTM D-1141 Standard.General corrosion and pitting in this solution is less severe than in a 3 % NaCℓ-solution. Initiation of stress corrosion cracking in this environment occurs faster than in a 3 % NaCℓ-solution, at least if a freshly prepared solution is used. Addition of H_2O_2 to a NaCℓ-solution is effective in shortening the testing time, but it also increases the general corrosion and pitting.

The pretreatment as described by the LN 65666 is a reason of concern. Although the results of the present experiments are not fully consistent, it is shown that the material surface is attacked by this pretreatment. Combined with the results of Schra et.al., who proved that the degree of surface attack depends on the type of aluminium alloy [ref. 4], the conclusion should be that this pretreatment is not suitable for stress corrosion experiments with aluminium alloys.

Again it is shown that the constant strain rate method can be successfully used in stress corrosion experiments. The ranking with respect to the aggressiveness of the environments is the same for both the constant deformation method as well as for the constant strain rate method. Both the A-series environments as well as the B-series environments are ranked in the same order: A5-A3-A4-A1 and B3-B5-B4. The constant deformation tests are stopped after a test duration of 100 days, although in some environments only 2 out of 6 specimens had failed. The maximum test duration using the constant strain rate method (using the lowest strain rate of 5.8 x 10^{-8} sec^{-1}) was about 45 hours. The maximum testing time using the preferred strain rate of 2.9 x 10^{-7} sec^{-1}, is only 9 hours. Of course this time advantage is partially offset by the more complicated equipment that is needed and the fact that on one testing machine only one experiment at a time can be carried out.

The results of the present investigation also show a fairly good agreement with the results of the EAA Round Robin Programme. If the environments used in the EAA Programme are coded according to the coding used in this investigation, the ranking of the EAA environments (in order of decreasing aggressiveness) is: B3-A2-B5-B4. For the two lowest strain rates used in our experiments the ranking is: B3-B5-A1-B4. If the results obtained with the fairly high strain rate of 1.45 x 10^{-6} are considered the agreement is much less: B3-B4-B5-A1. However, the differences between B4, B5 and A1 are only minimal.

5. CONCLUSIONS

- The German standard for stress corrosion testing of aluminium alloys, LN 65666, is not recommended. The pretreatment described by this method will result in a surface attack of the specimens. The addition of chromate-ions to reduce the general and pitting corrosion of the specimens is very effective, but it also reduces the aggressiveness of the environment.
- A better environment for stress corrosion testing of aluminium alloys is substitute ocean water. The chemical composition is described in the ASTM D-1141 standard. Good results are obtained in this environment, especially when the pH-value of the environment is reduced to pH3. In this environment general corrosion and pitting are less severe than in a 3 % NACℓ-solution, and a rapid initiation of stress corrosion cracks will occur.
- A very good agreement is found between the results obtained with the constant deformation method and those obtained with the constant strain rate method.
- In the constant strain rate experiments a strain rate of about 10^{-7} sec^{-1} was found to be a good compromise between the necessity to reduce the total testing time and the reliability of the results.
- A fairly good agreement exists between the results of this investigation and the results of the Round Robin Programme of the EAA Working Group on slow strain rate stress corrosion testing of aluminium alloys.

6. ACKNOWLEDGEMENT

The authors wishes to thank prof. J. Schijve for his useful remarks during the preparation of this report.

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8. TABLES AND FIGURES

Code	Environment	pH	Pretreatment	Constant Deformation	Constant Strain Rate
A1	2 % NaCℓ + 0.5 % Na_2CrO_4	3	LN 65666	X	X
A2	2 % NaCℓ + 0.5 % $K_2Cr_2O_7$	3	LN 65666	X	-
A3	3 % NaCℓ + 0.3 % H_2O_2	3	LN 65666	X	X
A4	3 % NaCℓ	3	LN 65666	X	X
A5	substitute ocean water	3	LN 65666	X	X
B3	3 % NaCℓ + 0.3 % H_2O_2	free	P_3RST	X	X
B4	3 % NaCℓ	free	P_3RST	X	X
B5	substitute ocean water	8.2	P_3RST	X	X
C3	3 % NaCℓ + 0.3 % H_2O_2	free	LN 65666	X	-
C4	3 % NaCℓ	free	LN 65666	X	-
C5	substitute ocean water	8.2	LN 65666	X	-

Table 1 : Overview of the combinations used in the experiments.

Environment code	no. of specimens failed	time-to-failure days	mean t-t-f days	standard deviation (days)
A1	1/1/4 1)	55/95/NF 1) 2)	-	-
A2	1/1/4	33/70/ND 2)	-	-
A3	1/5	5/6	5.8	0.41
A4	1/1/2/2	5/6/7/9	7.2	1.60
A5	2/4	4/5	4.7	0.52
B3	2/2/1/1	6/7/8/10	7.3	1.51
B4	1/1/1/1/1/1	10/14/15/16/17/18	15.0	2.83
B5	2/2/2	7/8/11	8.7	1.86
C3	2/2/1/1	6/7/8/11	7.5	1.87
C4	2/1/1/1/1	7/8/10/13/16	10.2	3.66
C5	1/2/1/1/1	10/13/14/21/NF 3)	14.2 4)	4.09 4)

1) Notation 1/1/4 | 55/95/NF = 1 spec. failed after 55 days
1 spec. failed after 95 days
4 spec. not failed

2) NF = not failed after 100 days

3) NF = not failed after 45 days

4) NF. specimen excluded

Table 2 : Time-to-fracture of the constant deformation specimens.

pretreatment	strain rate sec^{-1}	$\sigma_{0.2}$ MPa	σ_{max} MPa	σ_f MPa	δ_f %	t_f hrs
as machined	5.8×10^{-8}	528.3	574.8	556.5	12.9	45.17
	2.9×10^{-7}	535.8	584.3	572.7	11.7	8.72
	1.45×10^{-6}	534.8	581.5	567.0	11.9	1.75
	7.25×10^{-6}	537.5	587.4	576.0	11.6	0.35
LN 65666	5.8×10^{-8}	524.1	573.7	556.5	12.9	45.35
	2.9×10^{-7}	530.6	579.1	563.0	11.8	8.73
	1.45×10^{-6}	531.7	573.1	557.7	11.9	1.76
	7.25×10^{-6}	527.7	575.2	567.3	11.3	0.34

Table 3 : Influence of the strain rate and the pretreatment on the mechanical properties of the specimens.

Strain rate : 5.8×10^{-8} sec^{-1}			
Environment	$\sigma_{f\ corr}/\sigma_{f\ air}$	$\delta_{f\ corr}/\delta_{f\ air}$	$t_{f\ corr}/t_{f\ air}$
A1	0.969	0.778	0.885
A3	0.891	0.192	0.580
A4	0.833	0.268	0.579
A5	0.756	0.078	0.444
B3	0.943	0.262	0.638
B4	0.996	0.908	0.952
B5	1.010	0.471	0.753

Table 4 : Results of the constant strain rate tests.
Strain rate 5.8×10^{-8} sec^{-1}

Strain rate : 2.9×10^{-7} sec^{-1}			
Environment	$\sigma_{f\ corr}/\sigma_{f\ air}$	$\delta_{f\ corr}/\delta_{f\ air}$	$t_{f\ corr}/t_{f\ air}$
A1	0.988	1.010	0.968
A3	0.939	0.261	0.582
A4	1.006	0.875	0.928
A5	0.886	0.178	0.598
B3	0.973	0.446	0.725
B4	0.987	1.126	0.986
B5	0.977	0.977	0.923

Table 5 : Results of the constant strain rate tests.
Strain rate 2.9×10^{-7} sec^{-1}

Strain rate : 1.45 x 10^{-6} sec^{-1}			
Environment	$\sigma_{f\ corr}/\sigma_{f\ air}$	$\delta_{f\ corr}/\delta_{f\ air}$	$t_{f\ corr}/t_{f\ air}$
A1	1.004	1.131	1.023
A3	0.992	0.395	0.744
A4	1.019	0.832	0.901
A5	0.984	0.502	0.778
B3	1.024	0.662	0.825
B4	1.003	1.066	0.981
B5	0.999	1.094	0.997

Table 6 : Results of the constant strain rate tests.
Strain rate 1.45 x 10^{-6} sec^{-1}

Strain rate 7.25 x 10^{-6} sec^{-1}			
Environment	$\sigma_{f\ corr}/\sigma_{f\ air}$	$\delta_{f\ corr}/\delta_{f\ air}$	$t_{f\ corr}/t_{f\ air}$
A1	-	-	-
A3	0.992	1.011	0.941
A4	0.991	1.092	1.044
A5	0.995	0.931	0.971
B3	0.992	1.040	1.000
B4	-	-	-
B5	-	-	-

Table 7 : Results of the constant strain rate tests.
Strain rate 7.25 x 10^{-6} sec^{-1}

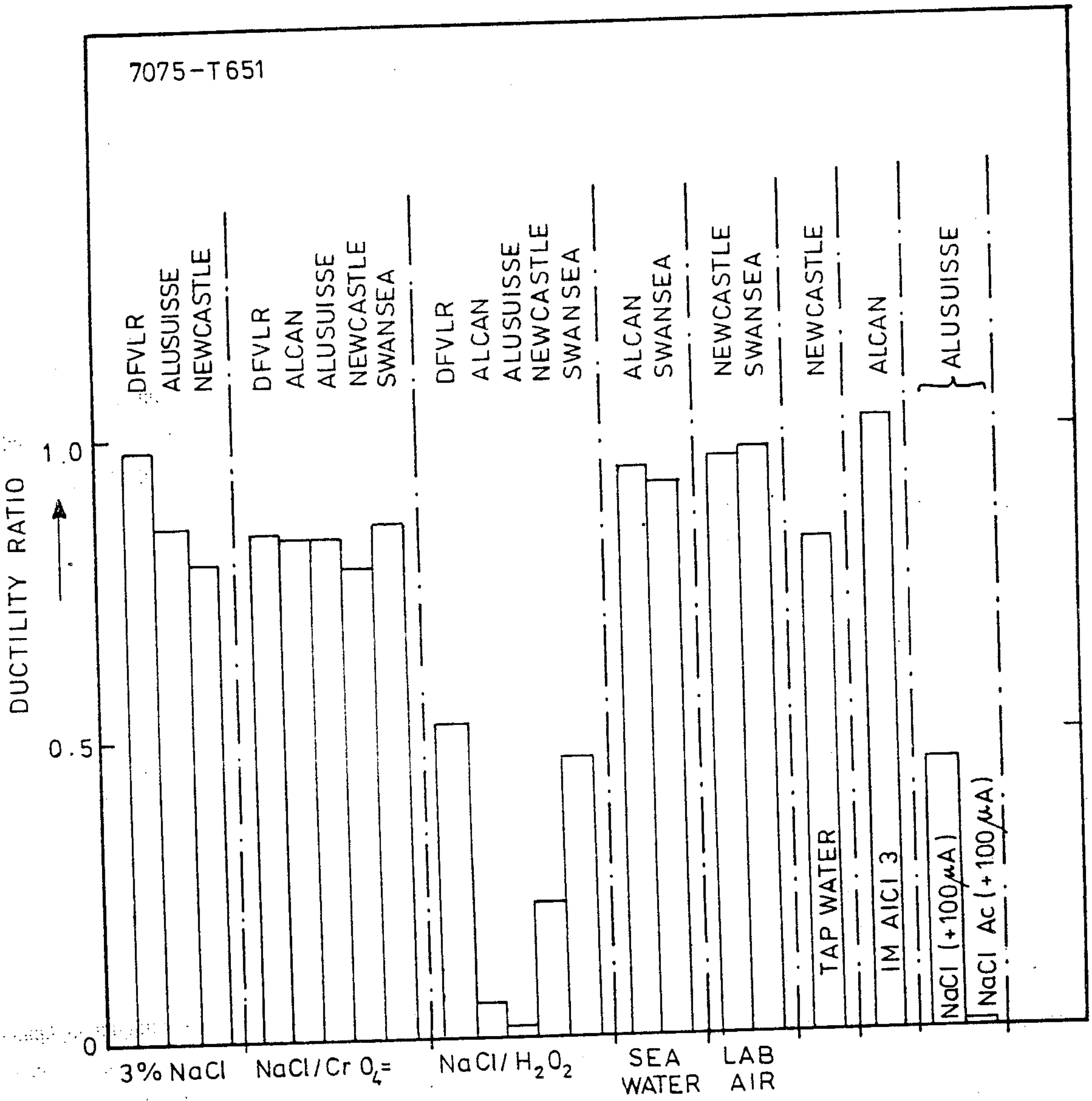
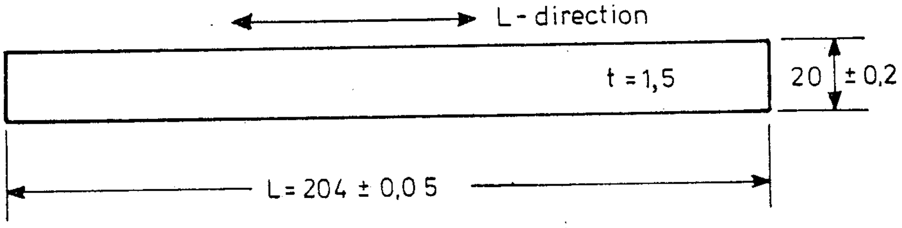
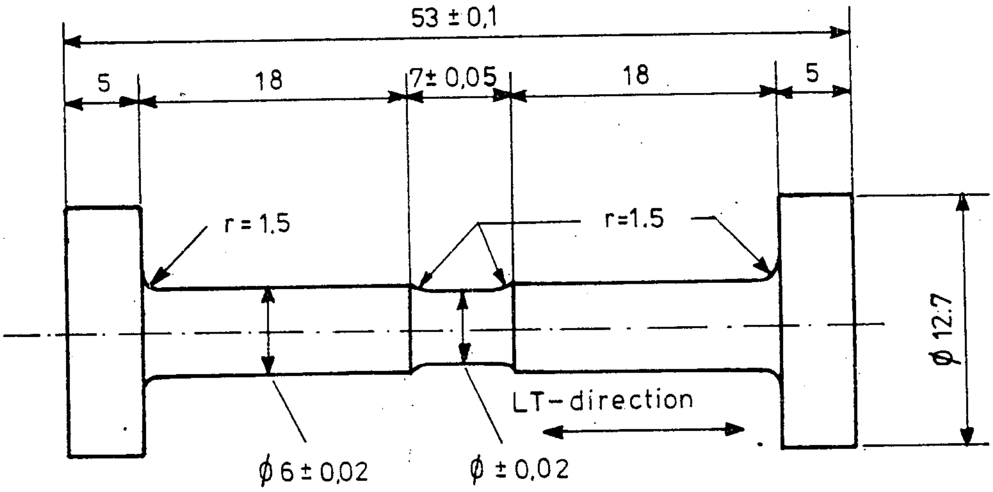


Figure 1 : Comparison of the results of the EAA Round Robin Programme tests on Aℓ-7075-T651 plate. Strain rate ∿ 10^{-6} sec^{-1}. Ref. [2].



a: constant deformation specimen



b: constant strain rate specimen

Figure 2 : Dimensions of the specimens (in mm)

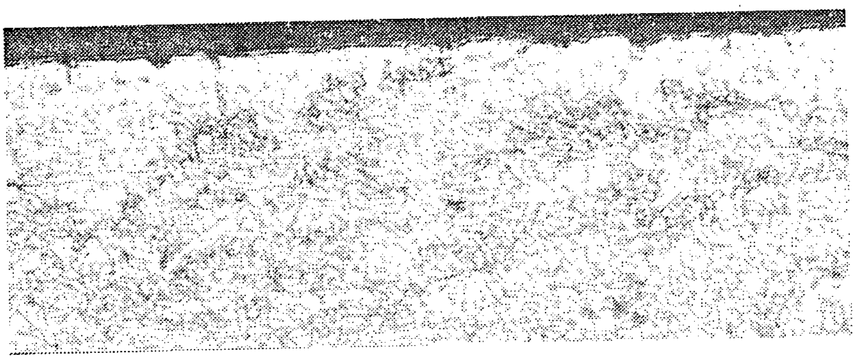


Figure 3 : Surface attack caused by the LN 65666 pretreatment (magn. 250 x).

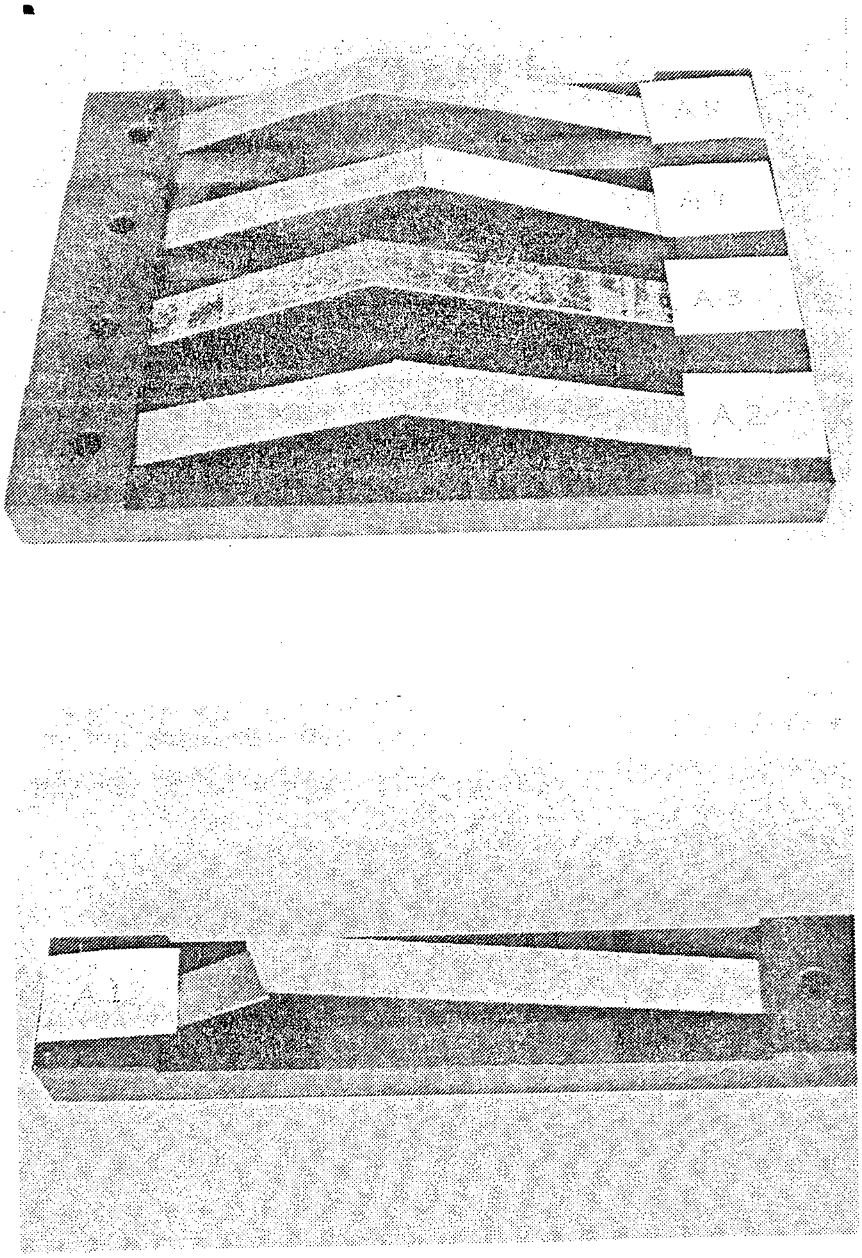


Figure 4: Appearance of the surfaces of the A-series specimens after the SCC-tests.

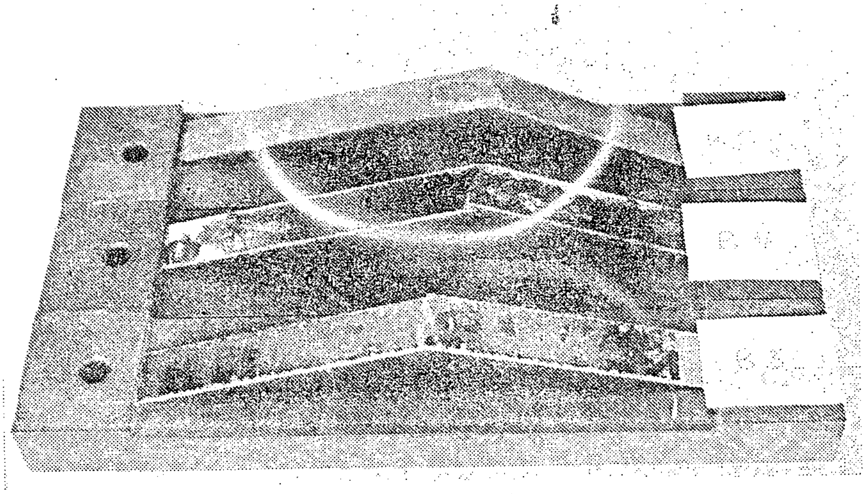


Figure 5: Appearance of the surfaces of the B-series specimens after the SCC-tests.

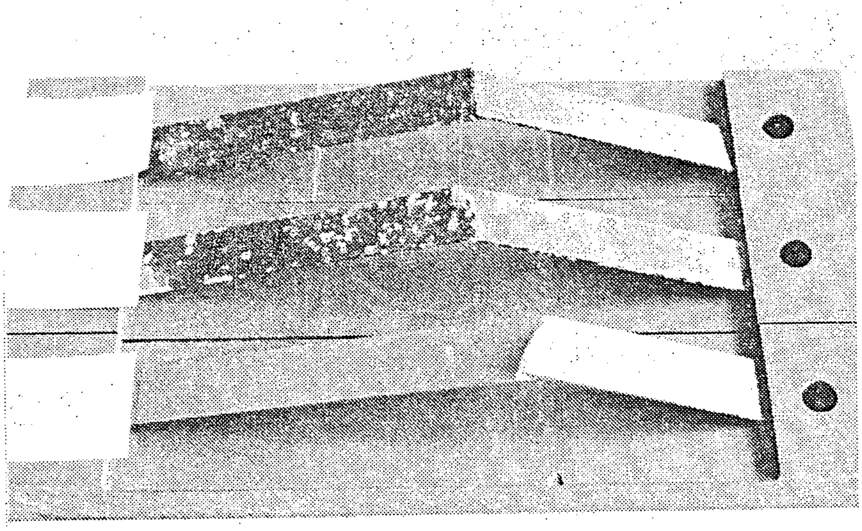


Figure 6: Appearance of the surfaces of the C-series specimens after the SCC-tests.

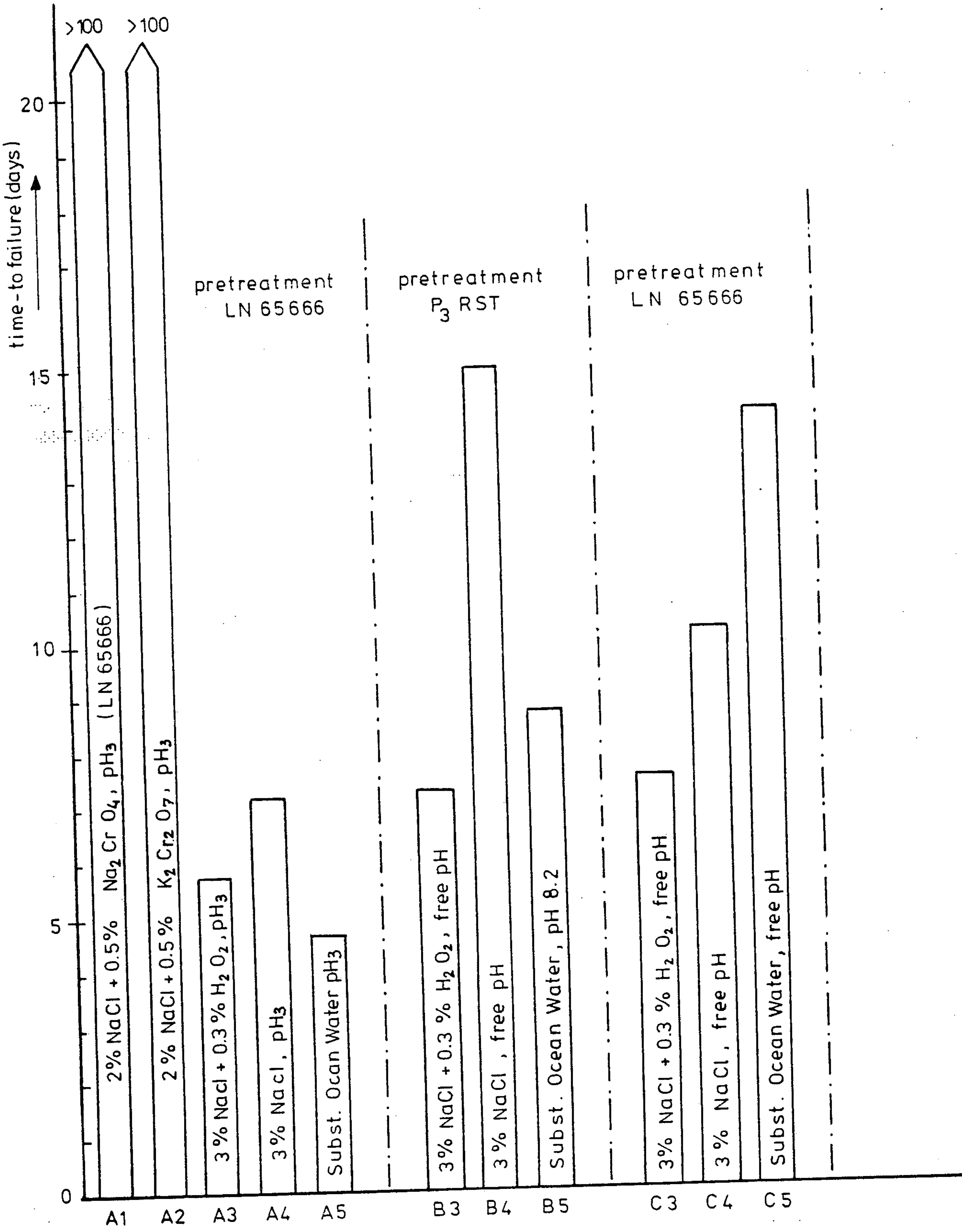


Figure 7 : Mean time-to-failure of the constant deformation specimens.

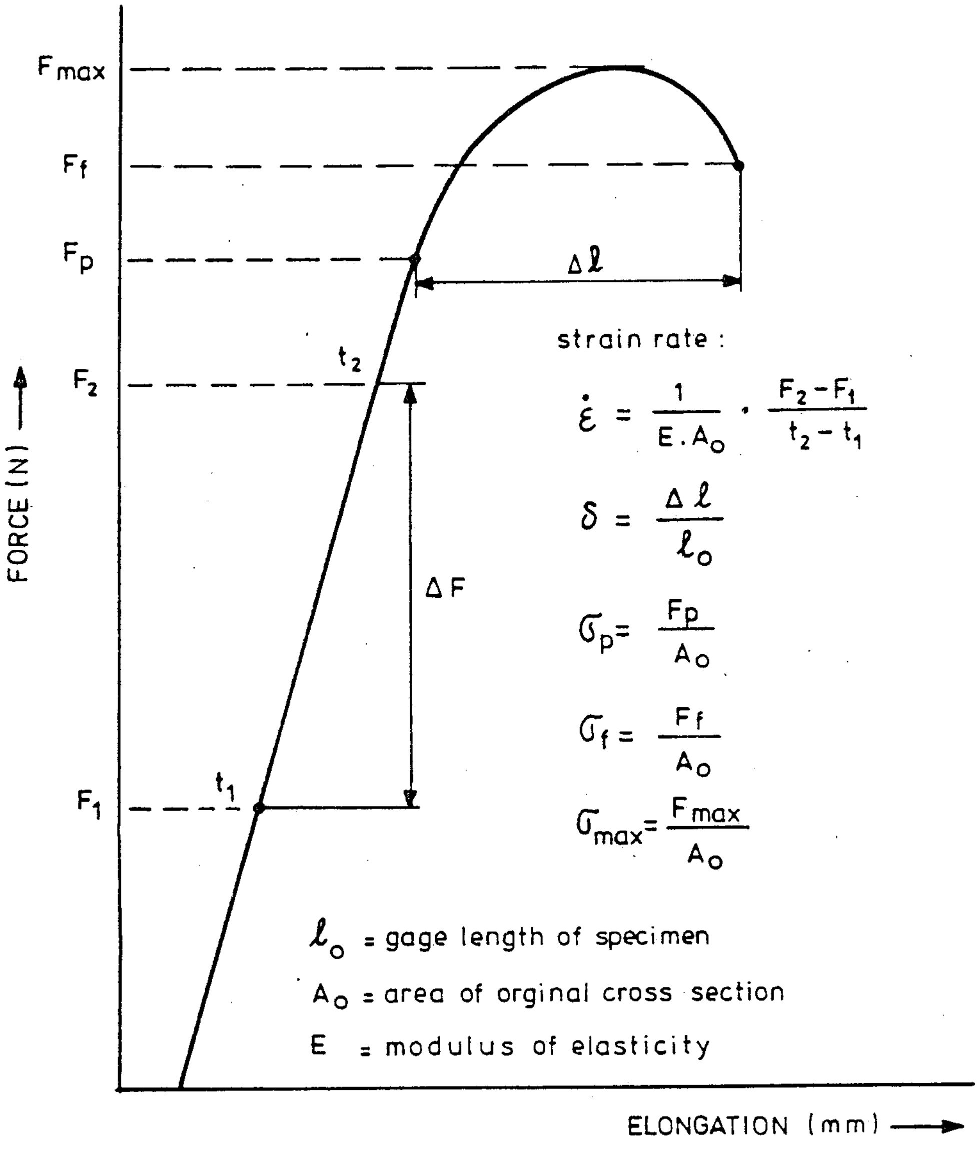


Figure 8 : Definitions of the SCC-criteria

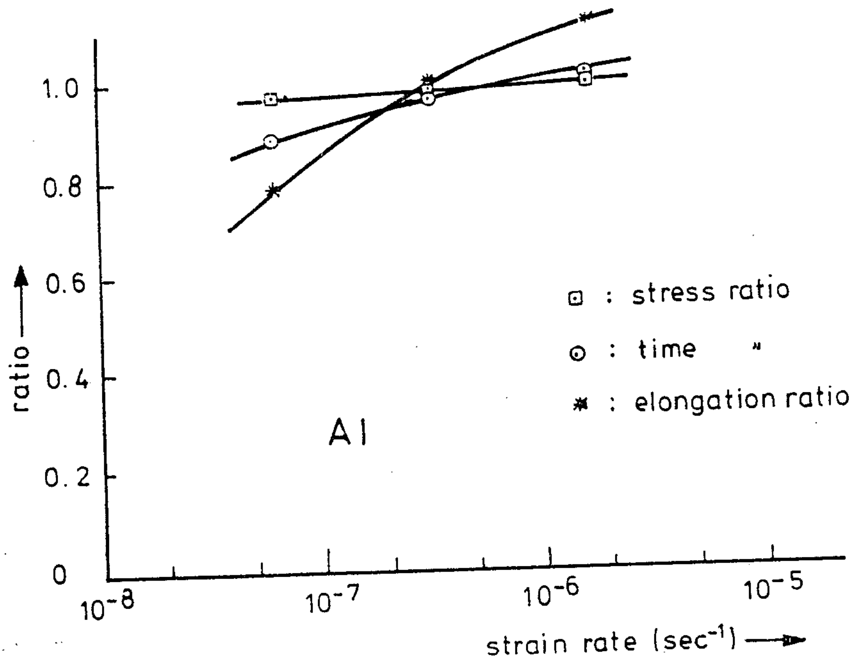


Figure 9a : Influence of the strain rate on the SCC-susceptibility (2 % NaCℓ + 0.5 % Na_2CrO_4, pH3)

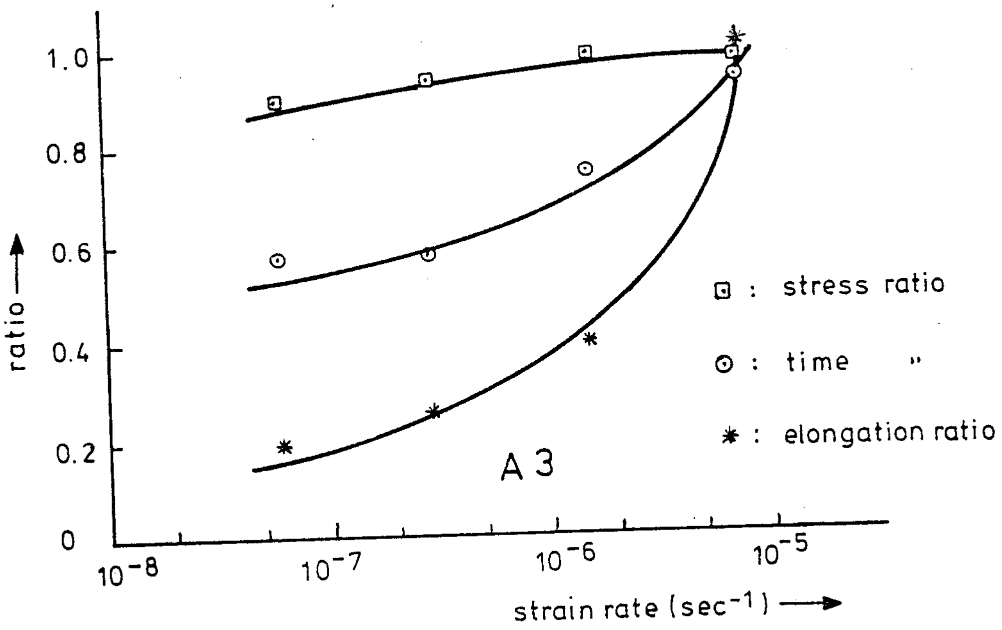


Figure 9 b: Influence of the strain rate on the SCC-susceptibility (2 % NaCℓ + 0.2 % H_2O_2, pH3)

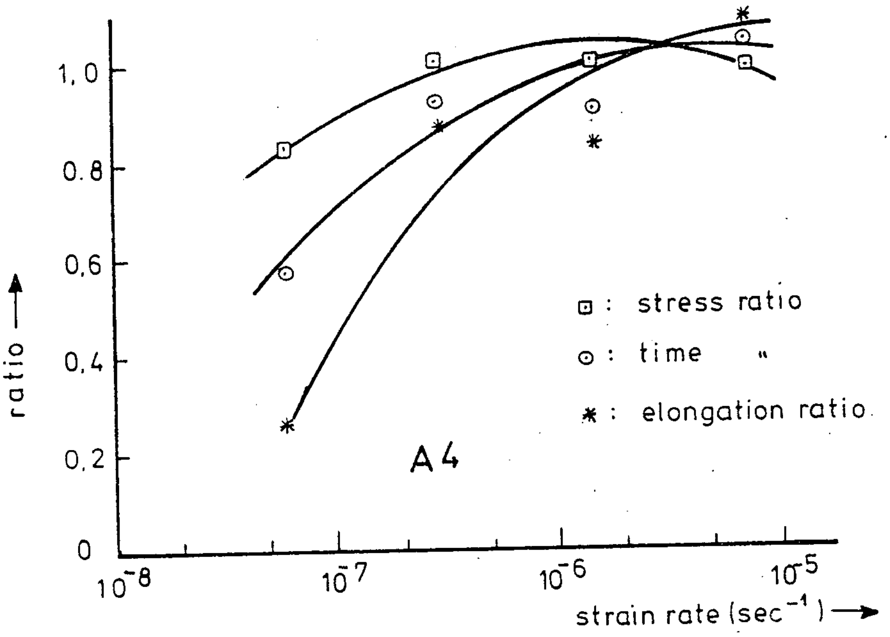


Figure 9 c: Influence of the strain rate on the SCC-susceptibility (3 % NaCℓ, pH3)

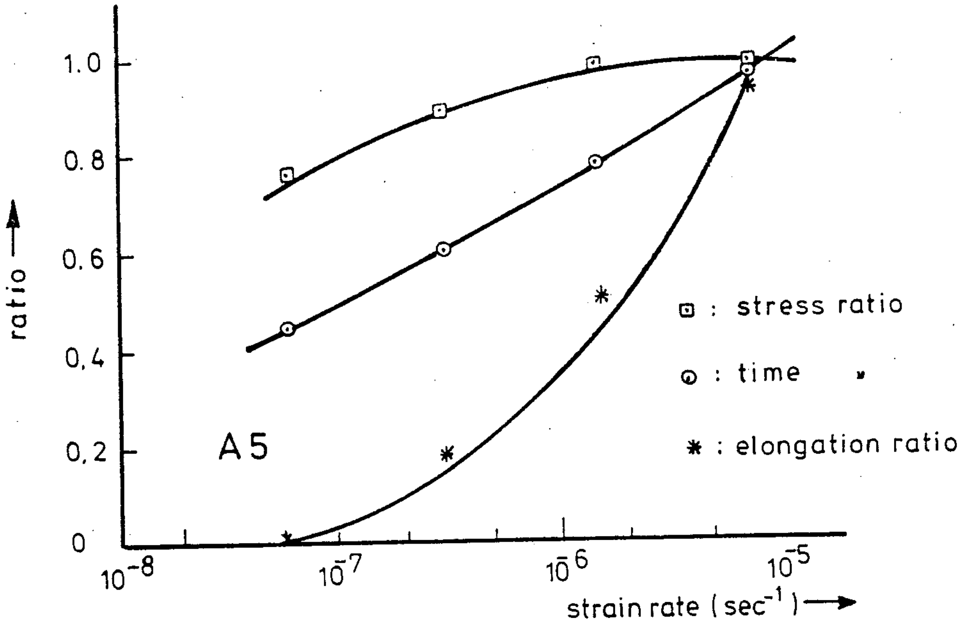


Figure 9 d : Influence of the strain rate on the SCC-susceptibility (subst. ocean water, pH3)

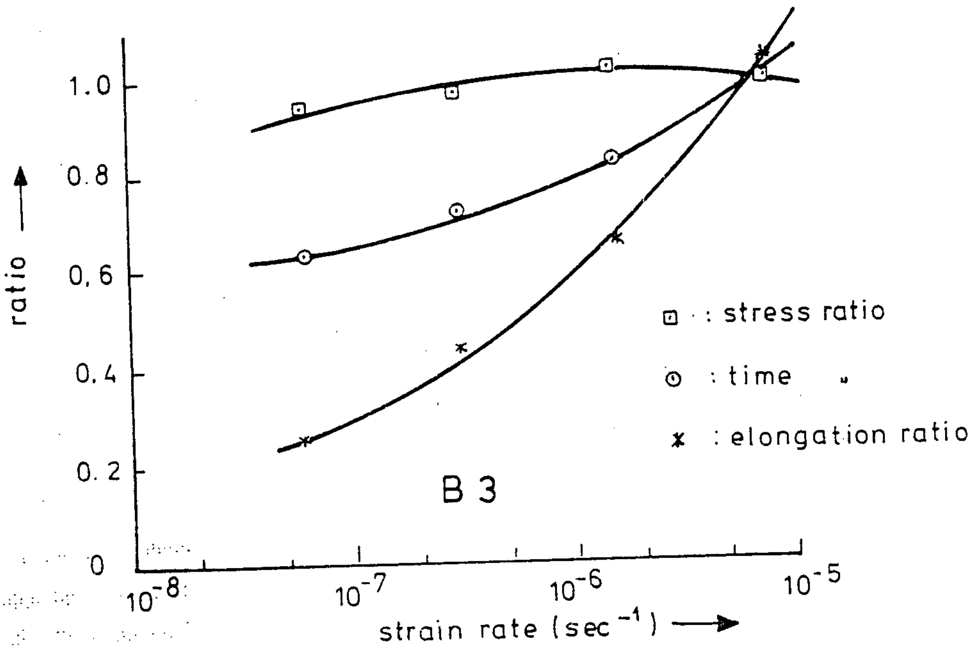


Figure 9 e : Influence of the strain rate on the SCC-susceptibility (3 % NaCℓ + 0.3 % H_2O_2, free pH)

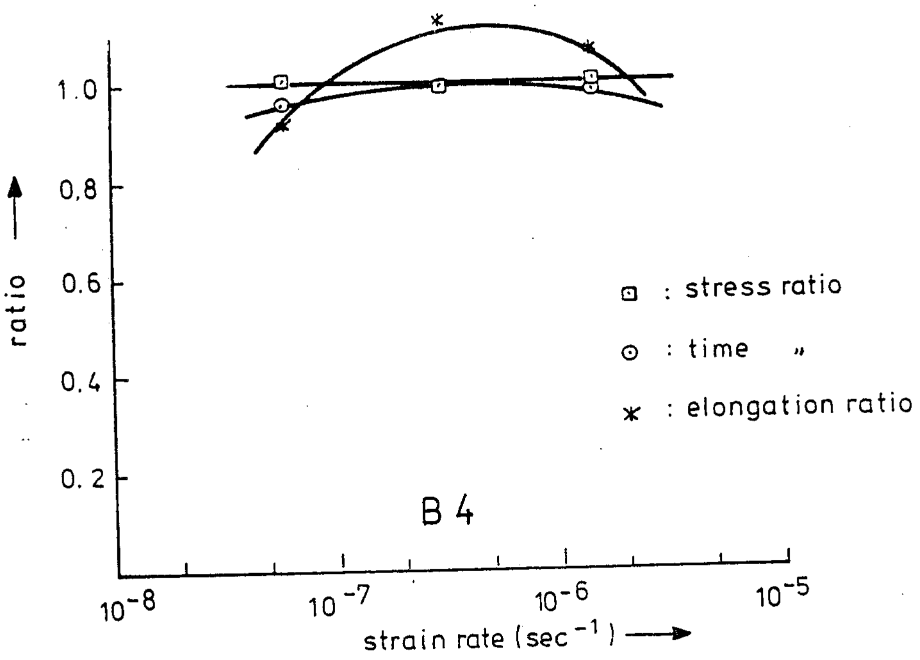


Figure 9 f : Influence of the strain rate on the SCC-susceptibility (3 % NaCℓ, free pH)

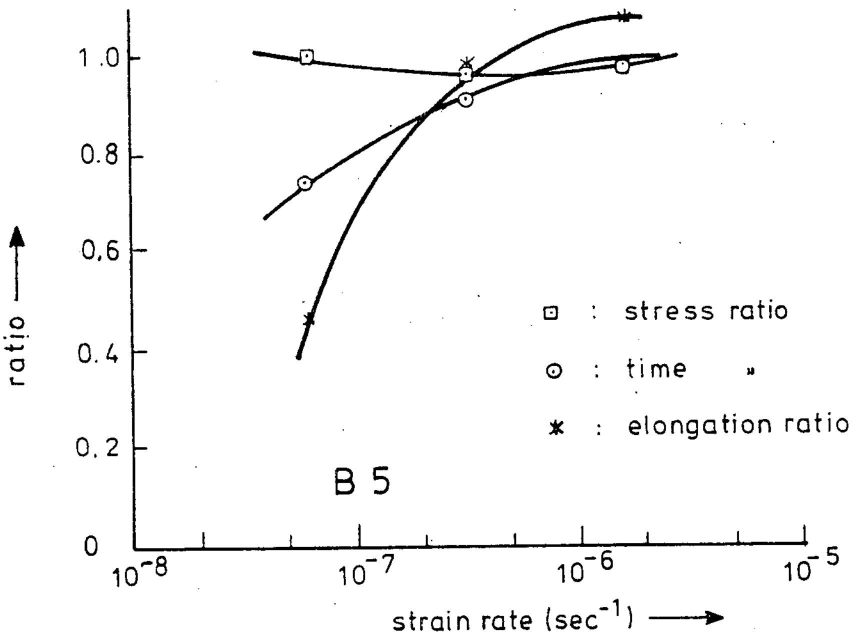


Figure 9 g : Influence of the strain rate on the SCC-susceptibility (subst. ocean water, Ph 8.2)

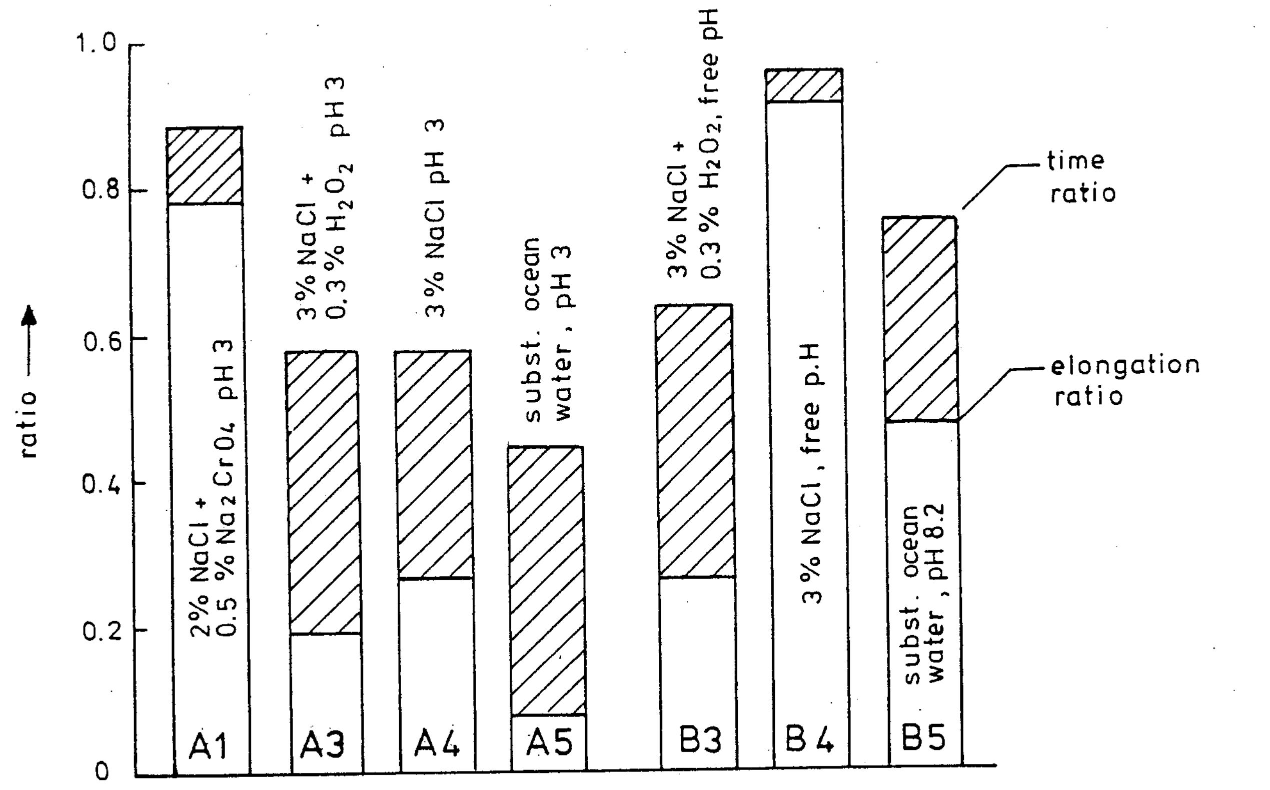


Figure 10 : Summary of the SCC-results for a strainrate of 5.8×10^{-8} sec^{-1}