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ECSS
FOR SPACE STANDARDIZATION

Space product assurance

Determination of the susceptibility of metals to stress-corrosion cracking

ECSS Secretariat
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Foreword

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ECSS-Q-70-37B	Never issued
ECSS-Q-ST-70-37C 15 November 2008	Second issue Redrafting ECSS-Q-70-31A according to ECSS drafting rules and new template.

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1
Scope

This document defines the requirements for the evaluation of the susceptibility of the SCC resistance.

It defines the preferred way to determine the susceptibility of metals and weldments to stress-corrosion cracking by alternate immersion in 3.5 % sodium chloride under constant load.

The results obtained from test programmes made according to this specification are used to classify alloys, weldments and their individual heat treatment conditions. When sufficient stress-corrosion data exists, the alloy designations can be submitted for inclusion into the various tables contained in ECSS-Q-ST-70-36.

In this document, the supplier is identified as the entity that performs the test.

This standard may be tailored for the specific characteristics and constrains of a space project in conformance with ECSS-S-ST-00.

2
Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply, However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies

ECSS-S-ST-00-01	ECSS system – Glossary of terms
ASTM G38 73 (1995)e1	Standard Practice for Making and Using C-Ring Stress-Corrosion Test Specimens
ASTM G39 90 (1994)e1	Standard Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens
DIN 50908 1993 04	Testing the resistance of aluminium wrought alloys to stress corrosion cracking

3 Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.

3.2 Terms specific to the present standard

3.2.1 residual strength

apparent UTS based upon nominal cross-sectional area

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00 01 and the following apply:

Abbreviation	**Meaning**
ASTM	American Society for Testing and Materials
CLA	centre line average
i.d.	inside diameter
o.d.	outside diameter
PVC	polyvinyl chloride
pH	hydrogen-ion concentration
SC	stress-corrosion
SCC	stress corrosion cracking
UTS	ultimate tensile strength

4 Principles

This standard covers constant-load stress-corrosion testing of metal specimens taken from welded or unwelded material. It is primarily intended for testing aluminium and ferrous alloys. The tests are carried out under alternate immersion conditions in 3,5 % sodium chloride over a thirty-day exposure period.

Unstressed control specimens are exposed to the same environment to provide a basis for comparison in assessing stress-corrosion susceptibility of materials that survive thirty days in the stress-corrosion test. This susceptibility is assessed by tensile tests, to compare the residual strengths of the exposed specimens, stressed and unstressed, and by metallographic examination of microsections from stressed and unstressed exposed specimens, to distinguish between stress-corrosion and intergranular-corrosion or pitting occurring independent of stress.

The requirements for the apparatus used for carrying out the test are set out in clause 5.2.3. Details of the preferred apparatus are given in Annex C but can be varied provided that the requirements set out in clause 5.2.3 are met.

Some wrought alloys commonly show greatest susceptibility to stress-corrosion when stressed in the short transverse direction. When such materials are subject to short transverse stressing in service, stress-corrosion tests are carried out under tensile stress applied in the short transverse direction. The test method covered by this specification is suitable for such tests assuming that the dimensions of the material to be tested provide short transverse specimens with a gauge length not less than 10 mm long. For other material short transverse stress-corrosion tests are carried out using C-ring specimens, bent-beam specimens or “tuning fork” specimens as described in ASTM G38-73(1995)e1, ASTM G39-90(1994)e1, or DIN 50908.

5
Requirements

5.1 Test condition

a. The supplier shall perform the stress-corrosion test for thirty-days.

NOTE Further details on the test method can be found in Annex B.

b. The test solution shall be 3.5 weight percent sodium chloride in water.

c. The test shall be carried out under alternate immersion conditions.

d. The test shall be performed at a temperature of 23 °C ±4 °C

e. During each period out of solution, the sample shall be left to dry out.

f. The supplier shall perform the test with nine flat or turned tensile test specimens split up in the following three sets:

1. Three specimens are used to determine the initial tensile properties of the material.
2. Three specimens are loaded in tension to the specified stress.
3. Three specimens are used for unstressed controls.

5.2 Preparatory conditions

5.2.1 Types of samples

a. The supplier shall test samples in the form of tensile test specimens which shall be either turned bars or special specimens machined from flat material as specified in clause 5.2.2.

b. The supplier shall produce test specimens so that the direction of the test stress represents the direction of stress in service.

c. When stress-corrosion tests are being carried out on wrought aluminium alloys, the supplier shall cut stress-corrosion test specimens so that the stress is applied in the short transverse direction.

d. For tests on welded material the supplier shall make welds according to the specification laid down for the equipment or component to which the stress-corrosion tests relate.

e. The supplier shall cut the test specimens so that the weld is situated at the centre of the gauge length.

NOTE In tests using flat specimens the surface of the sample is machined to remove the weld bead -

giving a smooth surface for the full gauge length of the specimen.

f. The supplier shall cut the specimens subjected to stress-corrosion tests from material in the same condition as the components that are used in service.

5.2.2 Details of test specimens

5.2.2.1 General

a. The supplier shall remove all sharp edges from the test specimen.

b. The supplier shall identify the samples by 1 to 9.

c. For turned stress-corrosion test specimen, the supplier shall use a letter height of 1.5 mm for the identification of the sample.

d. For flat stress-corrosion test specimen, the supplier shall use a letter height of 3.5 mm for the identification of the sample.

e. The location of the identification shall be as marked in Figure 5-1 and Figure 5-2.

5.2.2.2 Turned stress-corrosion test specimen

a. Where the shape and size of the material to be tested permits, the supplier shall use a turned specimen of the type shown in Figure 5-1.

b. The supplier shall make the diameter of the parallel end pieces and the form of thread to suit the shackles of the tensile test machine and the stress-corrosion apparatus.

c. The supplier shall prepare the turned test specimen with the following characteristics:

1. A diameter with more than 10 mm.
2. A gauge length of 50 mm as shown in Figure 5-1.

   NOTE This is valid for unwelded material and for most weldments.

3. A gauge length of at least 10 mm beyond the heat affected zone on each side of the weld for welded specimens.

   NOTE The plain parallel portion of the test piece between the threaded end and the shoulder is provided to facilitate sealing the bottom of the surrounding cell to the test piece and to provide latitude in adjusting the solution level within the cell to come above the gauge length but below the top shackle.

5.2.2.3 Flat stress-corrosion test specimen

a. For specimens to be taken from material less than 12 mm thick, the supplier shall use flat specimens of the type shown in Figure 5-2.

b. For the gauge length the supplier shall meet the requirements as for the machined specimens shown in Figure 5-1.

c. The supplier shall prepare the flat test specimen with the following characteristics:

1. A thickness of 5 mm giving a cross section of 50 mm^2 in the gauge length.
2. A width of the end section which is at least 20 mm greater than the diameter of the shackle-pin hole.

NOTE 1 The dimensions of the end sections shown in Figure 5-2 are suitable for use with 10 mm diameter shackle pins in the tensile test machine and stress-corrosion jigs.

NOTE 2 The end sections can be altered to suit the test apparatus available

NOTE 3 If the width of the end section minus the diameter of the shackle-pin hole is less than 20 mm, failures can occur across the centre line of the shackle-pin instead of in the gauge length.

d. The supplier shall machine the specimens to a finish of 0,5 micron CLA or better.

e. The supplier shall radius the edges of flat specimens by abrasion using fine silicon carbide paper with a grade of 1200.

f. The supplier shall not use polishing papers that contain oxides of iron for this purpose.

NOTE Use of polishing paper can accelerate pitting during exposure of the specimen to the saline solution.

5.2.2.4 Short transverse specimens

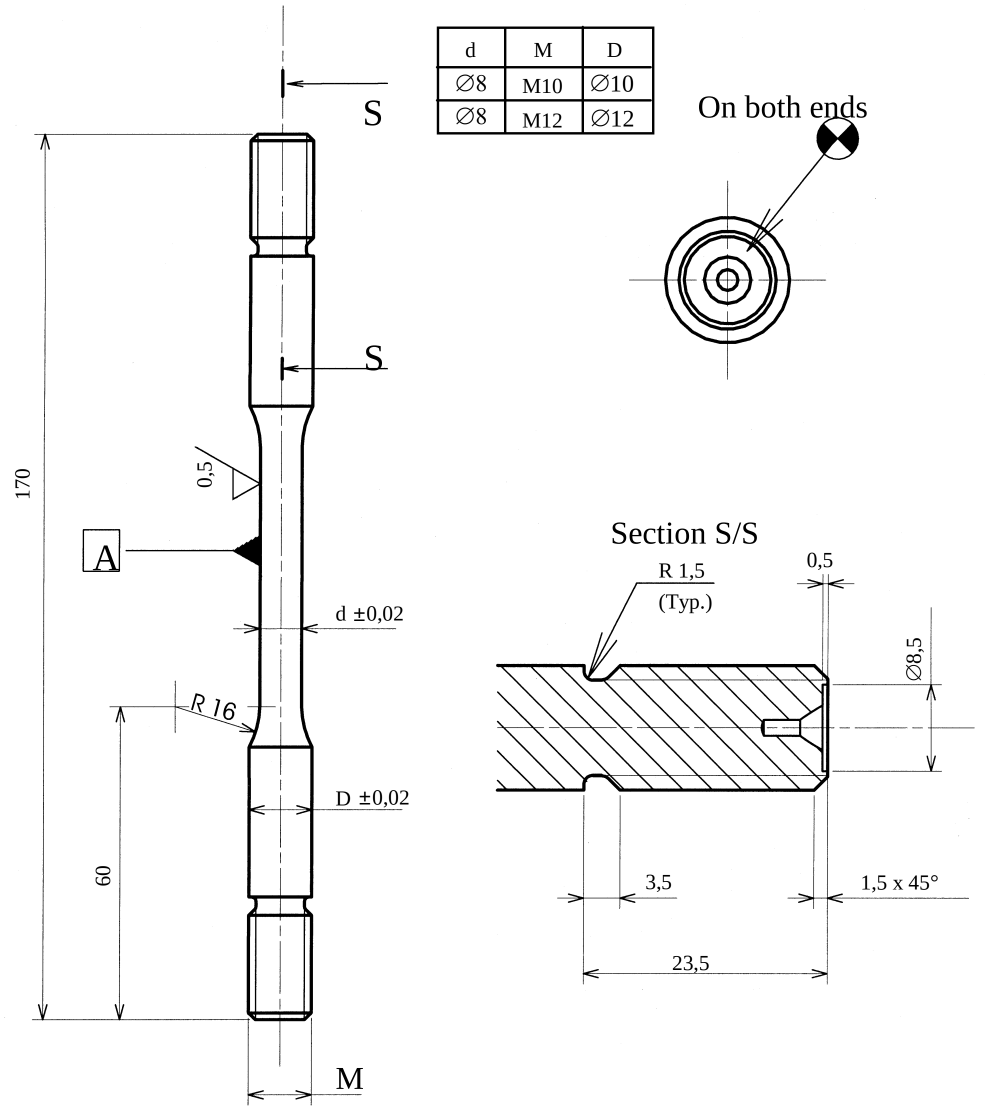
a. The supplier shall prepare the short transverse test specimen with the following characteristics:

1. Gauge length of the modified specimen not less than 10 mm.
2. Length between the gauge and threaded portions of turned specimens not less than 10 mm.
3. A minimum of 10 mm all round the shackle-pin holes of flat specimens.

b. When test is performed on short transverse specimens, the other dimensions of the specimen shown in Figure 5-1 and Figure 5-2 shall be reduced and agreed with customer

c. When a wrought alloy shows a greatest susceptibility to SC in the short transverse direction and is also subject to short transverse stressing in service, the supplier shall carry out tests under tensile stress applied in the short transverse direction.

d. For other cases, the supplier shall carry out short transverse stress-corrosion tests using C-ring specimens, bent-beam specimens or “tuning fork” specimens as described in ASTM G38 73(1995)e1, ASTM G39 90(1994)e1, or DIN 50908.

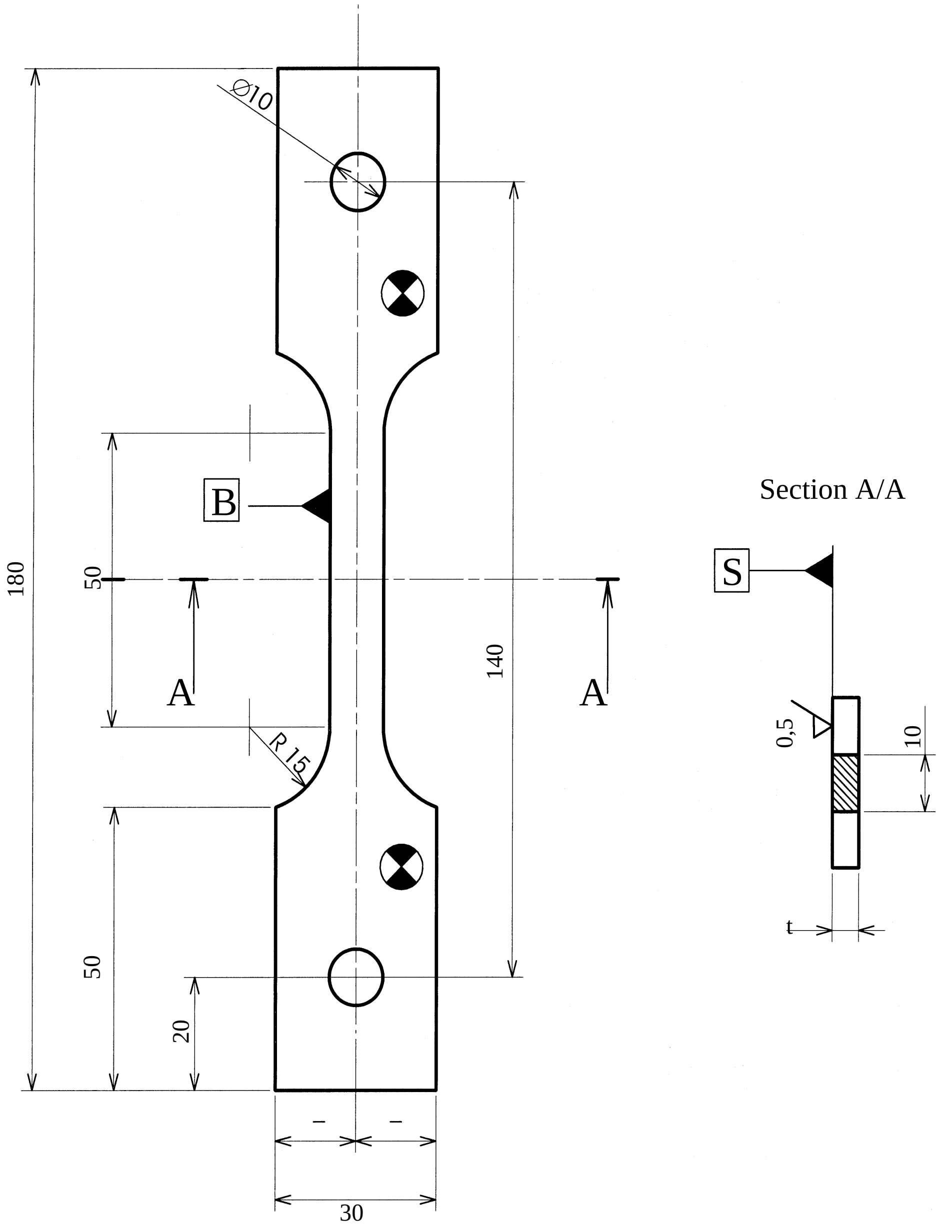


d	M	D
Ø8	M10	Ø10
Ø8	M12	Ø12

Notes:
1. Sample identification : location is marked by ⊗
2. Dimensions of drawing in mm and not to scale

Overall geometric tolerances		
General dimensions :	Js13; js13	
Surface roughness :	1,6 µmm	
Cylindricity	0,01	⌭
Symmetry:	0,1	⌯
Concentricity:	0,03 A	◎

Figure 5-1: Preferred turned stress-corrosion test specimen



Notes:
1. Sample identification: location is marked by ⊗
2. Dimensions of drawing in mm and not to scale

Overall geometric tolerances		
General dimensions:	Js13; js13	
Surface roughness:	1,6 µmm	
Flatness:	0,05/100	⏥
Parallelism:	0,02/100 S and B	//
Perpendicularity:	0,02 B	⊥
Symmetry:	0,02	⌯

Figure 5-2: Preferred flat stress-corrosion test specimen

5.2.3 Conditions for test apparatus

a. The supplier should use and apply the design rules as detailed in Annex C for the test apparatus.

NOTE This utilizes the compression of a pre-calibrated spring to apply the desired axial tensile stress to the specimen under test. The specimen is surrounded by an open-topped cell which is flooded with 3.5 % sodium chloride solution for ten minutes in each hour. Failure of the specimen is automatically recorded by the operation of a microswitch beneath the lower specimen support plate.

b. The supplier shall find an agreement with the customer whether to use the preferred test apparatus or an alternative test apparatus.

c. In case that the supplier uses an alternative test apparatus, the supplier shall design and use the apparatus in conformance with clause 5.2.4.

5.2.4 Alternative test apparatus

a. The supplier shall use a spring with a characteristic that slight yielding or creep of the specimen during the test does not alter the load applied by the spring.

NOTE This is achieved in the preferred test apparatus by employing springs requiring a compression of about 50 mm to produce a typical desired load. Other springs can be used which specify a compression of between 30 mm and 70 mm to produce the desired load.

b. The supplier shall design the apparatus such that the load is applied to the specimen through shackles which provide automatic alignment so that the applied tensile stress is axial with respect to the specimen.

c. The supplier shall make provision for automatic recording of the time of failure of the stress-corrosion specimen.

d. The supplier shall design the dimensions of the cells surrounding the stress-corrosion specimens and the unstressed control specimens such that the surface of the sodium chloride solution is above the top of the gauge length of the specimen, but below the top shackle, when the cell is flooded.

e. The supplier shall design the dimensions of the cells surrounding the stress-corrosion specimens and the unstressed control specimens such that the gauge length dries out during the fifty minute interval between successive ten-minute periods.

f. The supplier shall seal the bottom of the cell to the specimen below the gauge length or to the lower shackle.

g. The supplier shall protect the shackle against contact with the solution.

h. The supplier shall provide a separate reservoir containing 1 litre of the 3,5 % sodium chloride solution for each pair of specimens.

NOTE The pair of specimens consists of one stress-corrosion specimen and one unstressed control.

i. The supplier shall use a mechanical or pneumatic device for alternately flooding and draining the cells surrounding the specimens which automatically raises and lowers the solution reservoir.

5.3 Acceptance criteria

5.3.1 Test stress

a. For unwelded specimen, the supplier shall calculate the stress-corrosion test load from the average 0,2 % proof stress value provided by the three specimens tensile tested initially.

b. For unwelded specimen, the supplier shall carry out SC tests at 75 % of the 0,2 % proof stress.

NOTE Materials that have been characterized to possess a medium or low resistance to stress-corrosion cracking can be further tested to establish their stress-corrosion threshold. When these materials are loaded in the short transverse direction in service under conditions where the load can be controlled, tests at 50 % of the proof stress or even lower values can be called for.

c. For welded specimen, the stress-corrosion test load shall not exceed 75 % of the proof stress of the welded test bar.

NOTE Since yielding in welded test bars occurs usually in the weld bead, the proof stress for such specimens depends upon the ratio of weld bead width to gauge length.

d. For welded specimen, the supplier shall relate the selection of the test stress, to the nominal proof stress of the parent metal and to the design stress.

NOTE For welded materials it is important to allow for possible assembly stresses. This is best expressed in absolute units rather than as a percentage.

5.3.2 Metallographic examination

a. The supplier shall mount, ground and polish the longitudinal microsections by standard metallographic procedures.

NOTE The longitudinal microsections are taken as described in Annex B.1j.

b. The supplier shall examine the longitudinal microsections at a magnification of ×50 for evidence of stress-corrosion cracking.

c. When stress-corrosion cracking exists, the supplier shall record the maximum depth of pits.

NOTE Stress-corrosion cracks can initiate from these pits.

d. The supplier shall examine any apparent cracks in greater detail at ×500 magnification to establish whether they are true stress-corrosion cracks running through virtually uncorroded metal or tensile cracks running through areas of intergranular corrosion.

NOTE Most aluminium alloys stress-corrosion cracks generally follow intergranular paths.

e. The supplier shall examine the characterization of a crack as due to stress-corrosion is facilitated by comparison of microsections taken from the specimens tested, stressed and unstressed.

NOTE Any cracking found in the unstressed control specimens examined after tensile testing is probably not due to stress-corrosion, and similar cracking observed in the corresponding stress-corrosion specimens cannot be considered to be due solely to the stress-corrosion test.

5.3.3 Assessment of stress-corrosion susceptibility

5.3.3.1 General

a. The supplier shall classify the materials tested as showing resistance to stress-corrosion; either:

1. High, in conformance with 5.3.3.2
2. Moderate, in conformance with 5.3.3.3
3. Low, in conformance with 5.3.3.4.

5.3.3.2 Class 1 – high resistance to stress-corrosion

a. The supplier shall classify alloys or weldments as high if the following applies:

1. none of the three stress-corrosion specimens fails in the thirty day test. Any failure is disregarded if the tensile strength of the unstressed control specimen removed from test at the time of failure of the stress-corrosion specimen does not exceed the stress-corrosion test stress; and
2. the average tensile strength of two of the three stress-corrosion specimens after the thirty day test is not less than 90 % of that of the unstressed control specimens; and

3. none of the three stress-corrosion specimens shows evidence of stress-corrosion on metallographic examination at ×50 magnification.

5.3.3.3 Class 2 – moderate resistance to stress-corrosion

a. The supplier shall classify alloys or weldments as moderate if the following applies:

   1. none of the three stress-corrosion specimens fails in the thirty-day test. Any failure is disregarded if the tensile strength of the unstressed control specimen removed from test at the time of failure of the stress-corrosion specimen does not exceed the stress-corrosion test stress; and

   2. the average tensile strength of the two stress-corrosion specimens after the thirty-day test is not less than 90 % of that of the unstressed control specimens; and

   3. metallographic examination at ×50 magnification shows evidence of stress-corrosion in any of the three stress-corrosion specimens.

5.3.3.4 Class 3 – low resistance to stress-corrosion

a. The supplier shall classify alloys or weldments as low if the following applies:

   1. any of the three stress-corrosion specimens fails in the thirty-day test at a test stress below the tensile strength of the unstressed control specimen removed from test when the stress-corrosion specimen fails; and

   2. the average tensile strength of the stress-corrosion specimens after the thirty-day test is less than 90 % of that of the unstressed control specimens; and

   3. metallographic examination at ×50 magnification shows evidence of stress-corrosion.

5.4 Quality assurance

5.4.1 Data

a. The supplier shall retain the quality records for ten years or in accordance with project business agreement requirements.

   NOTE Example of such quality records are log sheets.

b. The supplier shall provide the test report in conformance with Annex A for customer approval.

5.4.2 Calibration

a. The supplier shall calibrate any measuring equipment to traceable reference standards.

b. The supplier shall record any suspected or actual equipment failure as a project nonconformance report in conformance with ECSS-Q-ST-10-09.

NOTE This is to ensure that previous results can be examined to ascertain whether or not reinspection and retesting is necessary.

Annex A (normative) Stress corrosion test report - DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-37, requirement 5.4.1b.

A.1.2 Purpose and objective

The purpose of this report is to summarize all information, relevant for stress-corrosion testing.

A.2 Expected response

A.2.1 Scope and content

<1> Material

a. The report shall include the material specification, form, actual composition and condition.

NOTE For example, heat treatment, room temperature, ageing after solution treatment or welding are possible conditions

b. The report shall include the material identification code.

NOTE For example, this can be the manufacturers' batch number.

c. For welded material, the report shall include details of weld process, filler metal composition and post-weld heat treatment and natural ageing period.

<2> Specimens

a. The report shall contain the following information about the specimens

1. type
2. dimensions

3. grain size

4. grain orientation

<3> Test conditions and apparatus

a. The report shall describe the used stress level.

b. The report shall provide evidence of conformances to design requirements for test apparatus

<4> Results

a. The test report shall list the lives of stress-corrosion specimens.

b. The test report shall list the time of failure occurred during the test.

c. The test report shall contain 0,2 % proof stress and tensile strength of all specimens subjected to tensile testing.

d. The report shall include the metallographic observations for the stress-corrosion specimens and the unstressed control specimens.

<5> Assessment

a. The report shall contain the classification of material tested as showing high, moderate or low resistance to stress-corrosion.

<6> Nonconformance

a. The report shall contain any nonconformance on equipment, material or test specimen.

A.2.2 Special remarks

None.

Annex B (informative) Test method

B.1 Procedure

a. Nine flat or turned tensile test specimens as detailed in clause 5.2.2 are prepared for the test. Three are used to determine the initial tensile properties of the material. Three are loaded in tension to the specified stress (see clause 5.3.1) in a spring loaded test jig which provides an axial constant load. Detailed requirements for the test jigs are given in clause 5.2.3. Each stress-corrosion specimen is surrounded by a cell which is flooded with 3,5 % sodium chloride for ten minutes in each hour. A timing device is connected to a microswitch operated by the displacement of the jig which occurs when the specimen breaks.

b. The third set of three specimens is used for unstressed controls. These specimens are supported vertically in individual cells of the same type as those which surround the stress-corrosion specimens, the cells being flooded with the same solution and at the same times as the stress-corrosion specimen cells.

c. The 3,5 % sodium chloride test solution is made to ASTM G44-94 "Standard Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3,5 % Sodium Chloride Solution". One litre of solution is provided for each pair of specimens and is replaced after seven, fourteen and twenty-one days.

d. When any of the three stress-corrosion specimens fails it is removed from the test rig, washed with warm water and dried in a stream of warm air. The corresponding unstressed control specimen is taken out at the same time and similarly washed and dried. Both are then stored in a desiccator until all three stress-corrosion specimens have failed or the thirty-day test period has been completed.

e. When the tests have been completed the unstressed control specimens corresponding to any stress-corrosion specimens that failed during the test are tensile tested, according to clause B.1 g, h and i, to determine their residual strength. Comparison of the residual strength of the unstressed control with that of the specimens tested initially and with the stress applied in the stress-corrosion test indicate to what extent the failure of the stress-corrosion specimen was due to stress-corrosion cracking and to what extent it was due to other forms of corrosion occurring independently of applied stress.

f. If none of the stress-corrosion specimens fails during the thirty-day test period two of them, and their corresponding unstressed controls, are tensile tested and submitted for metallographic examination. If any stress-corrosion cracking has occurred the residual strength of the stress-corrosion specimens is less than that of the corresponding unstressed controls. The third stress-corrosion specimen and its unstressed control are used for metallographic examination without tensile testing. (see Table B-1).

g. If one of the three stress-corrosion specimens fails during the thirty-day test, tensile tests are carried out at the end of the test period on the corresponding unstressed control, on one of the two unfailed stressed specimens and on its unstressed control. The third stress-corrosion specimen and its unstressed control are used for metallographic examination without tensile testing (see Table B-2).

h. If two of the three stress-corrosion specimens fail during the thirty-day test the remaining unfailed stressed specimen and its unstressed control are used for metallographic examination without tensile testing. Only the unstressed control specimens for the stress-corrosion specimens that failed are tensile tested (see Table B-3).

i. If all three of the stress-corrosion specimens fail during the thirty-day test they are submitted to metallographic examination. The first two unstressed control specimens to be withdrawn are tensile tested and then used for metallographic examination. The last unstressed control specimen to be withdrawn is not to be tensile tested, but is metallographically examined (see Table B-4).

j. Axial microsections across the full thickness are prepared from all the stress-corrosion and unstressed control specimens. From those which failed during the test, or were broken in subsequent tensile testing, the microsection is extended from the fracture surface for a distance of at least 20 mm. For welded specimens the total length of the microsection is extended at least 5 mm into the parent metal beyond the heat affected zone. Two adjacent microsections can be prepared if necessary to cover this length. For unbroken specimens, the longitudinal microsection is extended from one side of the centre of the gauge length for a distance of at least 10 mm or (for welded specimens) to a point 5 mm beyond the heat affected zone. The microsections are mounted and polished for metallographic examination as specified in clause 5.3.2.

k. The operations to be carried out during and at the end of the thirty-day test period are set out in tabular form in clause B.2 for examples in which different numbers of stress-corrosion specimens fail during the test period.

l. The criteria for assessment of stress-corrosion susceptibility from tests carried out according to this specification are set out in clause 5.3.3.

B.2 Treatment of specimens during and after thirty-day test period

Table B-1: Case A - No stress-corrosion specimen fails

	Specimen	Thirty-day exposure	Final tests after thirty days	
A1	initial mechanical test specimens			
A2				
A3				
A4	stress-corrosion specimens	30 days OK	Mechanical test	Metallography
A5		30 days OK	Mechanical test	Metallography
A6		30 days OK	→	Metallography
A7	unstressed control specimens		Mechanical test	Metallography
A8			Mechanical test	Metallography
A9			→	Metallography

Table B-2: Case B - One stress-corrosion specimen fails

	Specimen	Thirty-day exposure	Final tests after thirty days	
B1	initial mechanical test specimens			
B2				
B3				
B4	stress-corrosion specimens	20 days fail	→	Metallography
B5		30 days OK	Mechanical test	Metallography
B6		30 days OK	→	Metallography
B7	unstressed control specimens	Withdrawn after 20 days	Mechanical test	Metallography
B8			Mechanical test	Metallography
B9			→	Metallography

Table B-3: Case C - Two stress-corrosion specimens fail

	Specimen	Thirty-day exposure	Final tests after thirty days	
C1	initial mechanical test specimens			
C2				
C3				
C4	stress-corrosion specimens	20 days fail	→	Metallography
C5		15 days fail	→	Metallography
C6		30 days OK	→	Metallography
C7	unstressed control specimens	Withdrawn after 20 days	Mechanical test	Metallography
C8		Withdrawn after 15 days	Mechanical test	Metallography
C9			→	Metallography

Table B-4: Case D - All three stress-corrosion specimens fail

	Specimen	Thirty-day exposure	Final tests after thirty days	
D1	initial mechanical test specimens			
D2				
D3				
D4	stress-corrosion specimens	20 days fail	→	Metallography
D5		15 days fail	→	Metallography
D6		12 days fail	→	Metallography
D7	unstressed control specimens	Withdrawn after 20 days	→	Metallography
D8		Withdrawn after 15 days	Mechanical test	Metallography
D9		Withdrawn after 12 days	Mechanical test	Metallography

Annex C (informative) Design rules of test apparatus

a. Figure C-1 is an exploded sectional assembly drawing of the preferred apparatus for testing according to this specification. The tubular frame which forms the central member is a 350 mm length of 100 mm o.d. by 3 mm wall steel tube with a window 200 mm long by 125 mm wide machined in each side.

b. The bottom of the tubular frame is fitted with a bottom closure plate carrying a 125 mm length of 20 mm studding held by a securing nut at the bottom and screwing into a specimen outer shackle at the top. The opposite end of the outer shackle has a vertical slot 10 mm wide by 55 mm deep which engages with a tongue at the bottom end of the inner shackle. A 10 mm diameter steel pin holds the two shackles together and permits slight movement between them to maintain axial loading.

c. For use with threaded specimens of the type shown in Figure 5-1 the top of the inner shackle is drilled and tapped 12 mm. For use with the flat type specimen shown in Figure 5-2 the top of the inner shackle is slotted to receive the end of the specimen and a 10 mm diameter hole is drilled through to accept a shackle pin which passes through the hole in the end of the specimen.

d. The top end of the tubular frame is fitted with a top closure plate with a plain central hole in which a 500 mm length of 20 mm studding is a sliding fit. The length of studding carries a keyway which engages with a grub screw in the top closure plate to prevent the studding turning in relation to the plate during loading. The lower end of the length of studding screws into the outer member of a pair of shackles similar to those at the bottom of the jig.

e. The compression spring which provides the load to be applied to the specimen is located between the top closure plate and a spring end plate which is a sliding fit on the studding. Both plates have spigots to locate the spring and the ends of the spring are ground flat to seat squarely on the two plates.

f. The spring is compressed by means of a tensioning nut which operates against a thrust race. Between the thrust race and the spring end plate is a cross piece supporting two hook bolts the lower ends of which engage in the windows in the sides of the tubular frame. These are provided to limit the expansion of the spring when the specimen breaks.

g. The compression spring are selected to suit the load to be applied to the test specimen. For testing high and medium strength aluminium alloy specimens of the dimension shown in Figure 5-1 and Figure 5-2, springs with ten turns of 15 mm diameter steel having a total free length of 150 mm and an outside diameter of 105 mm have proved satisfactory. These springs produce a load of 20 kg for each 10 mm of compression and require a compression of about 50 mm to provide a typical desired load.

h. A tensile test machine is used to plot a calibration curve of load against compression for each spring. The calibration curves are used to calculate the compression required to apply the desired load to the test specimen. Centre punch marks are made on the top and bottom turns of the spring and the compression measured by locating the points of a pair of dividers in these marks.

i. The test specimen is surrounded by an alternate immersion cell details of which are given in step n to p.

j. To use the stress-corrosion test jig the parts are assembled with the exception of the top and bottom inner shackle. The specimen is fitted to the shackles and the alternate immersion test cell fixed in place. If flat specimens are used the part of the lower shackle which comes within the cell is coated with a suitable sealant.

NOTE It is important to avoid sealants which can produce corrosive chemical species during curing, e.g. acetic curing silicones.

The specimen, with the inner shackles and alternate immersion cell in place, is fitted into the test rig and located by inserting the pins which secure the inner shackles to the outer shackles. The tensioning nut is screwed down to take up the slack and a check is made to see that all the parts of the jig are correctly positioned so that the specimen is under axial load when the spring is compressed.

k. The specimen is loaded to the required stress by compressing the spring to the appropriate length measured between the centre punch marks upon it. This may be done by holding the top closure plate by means of a peg spanner fitted into holes drilled in the plate for that purpose and screwing down the tensioning nut against the thrust race. It is more convenient however to use a simple hydraulic jack type of loading device acting between the bottom closure plate and the spring end plate to compress the spring to the desired extent and then screw down the tensioning nut to retain the spring in that position when the loading device is removed. After loading the specimen the nuts on the restraining hook bolts are screwed down finger tight.

l. After loading, the jig is suspended vertically by passing the upper part of the 500 mm length of 20 mm studding through a hole in a suitable frame as shown in Figure C-2 and fitting a nut above the suspension plate of the frame. The frame incorporates a tray which is situated about 10 mm below the bottom closure plate of the stress-corrosion jig and has a central hole through which the lower securing nut of the jig passes freely. A microswitch is attached to the tray so that this movement alters the switch condition when the specimen breaks and the bottom closure plate drops. The microswitch is connected to an electrical timer which is started at the commencement of the thirty-day test period and stops automatically when the specimen breaks, thus recording its life.

m. The stress-corrosion tests are carried out in triplicate - three similar unstressed control specimens being tested at the same time. The unstressed controls are supported vertically in spare inner shackles similar to those used in the stress-corrosion jigs and are surrounded by similar alternate immersion cells, but their top ends are free.

n. The alternate immersion cell comprises a transparent rigid plastic tube 60 mm i.d. fitted into a moulded PVC lower end cap which forms a seal onto the lower, plain end-portion of the specimen if threaded-end specimens are used. If flat specimens are used it is difficult to get a satisfactory seal on the specimen itself; the seal is then made on the inner shackle. The parts of the shackle within the PVC end cap and the gap between the end of the specimen and the slot in the shackle is then sealed with a suitable compound.

o. A 5 mm diameter tube moulded into the bottom of the end cap is connected to a flask containing 1 l of 3,5 % sodium chloride the pH of which is adjusted to between 6,4 and 7,2 as specified in ASTM G44-94 “Standard Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3,5 % Sodium Chloride Solution”. Each flask serves two specimens, a stress-corrosion specimen and its unstressed control.

p. A pneumatic device operated by an electrical timer pressurizes the flask at fixed intervals causing the sodium chloride solution to flood into the cells surrounding the stressed and unstressed specimens for ten minutes in each hour. The maximum liquid level in the cell is set to come above the gauge length but below the bottom of the top inner shackle.

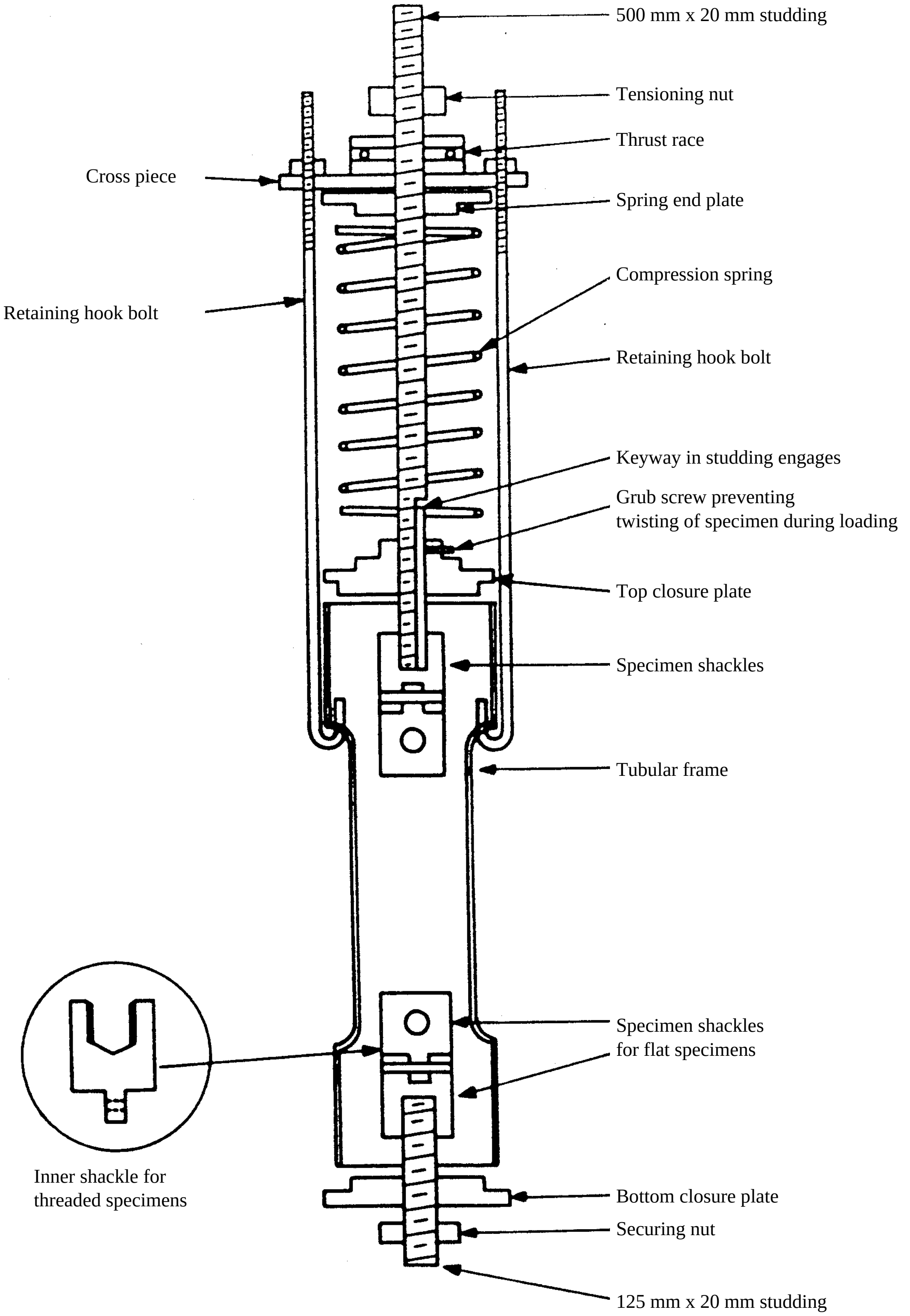


Figure C-1: Cross-section of stress-corrosion jig

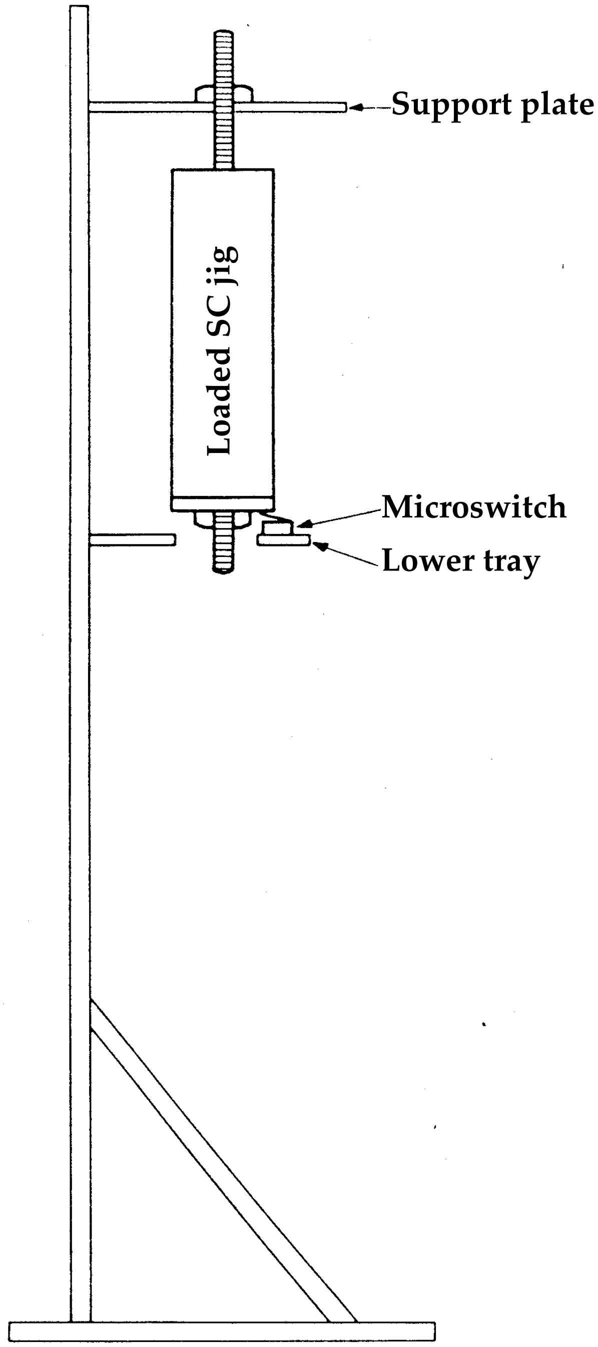


Figure C-2: Support frame for stress-corrosion jig

Bibliography

ECSS-S-ST-00	ECSS system – Description, implementation and general requirements
ECSS-Q-ST-70-36	Space product assurance – Material selection for controlling stress-corrosion cracking
ASTM G44 94	Standard Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3,5 % Sodium Chloride Solution