



Safety Information Bulletin

Airworthiness

SIB No.: 2018-04R1

Issued: 13 September 2018

Subject: Environmentally Assisted Cracking in certain Aluminium Alloys

Revision: This SIB revises EASA SIB 2018-04 dated 02 February 2018.

Ref. Publications: None

Applicability:

Type Certificate holders, Supplemental Type Certificate holders, equipment manufacturers, maintenance organisations, production organisations and aluminium alloy producers.

Description:

EASA received reports of brittle cracking of aluminium alloy components. Additional investigation of some new generation 7xxx series alloys has shown that these have a sensitivity to a phenomenon known as environmentally assisted cracking (EAC), when subject to certain conditions in the normal operating environment. The type of EAC encountered appears to be caused by hydrogen embrittlement along the grain boundaries, leading to crack initiation and subsequent propagation. These cracks typically start from holes or other areas of stress concentration and usually propagate in a plane perpendicular to the short transverse (ST) direction. This phenomenon has been linked to the chemical composition of the alloy, notably a high zinc/magnesium ratio, combined with low copper content. Brittle fractures have been reproduced under laboratory environment and cracking has proven to be driven by time exposure (ageing) and is not fatigue related, although further crack propagation under operative loads cannot be excluded.

Results of further investigation are in agreement with open scientific literature, and show that an EAC phenomenon can occur only when the three following conditions are present: (1) susceptible material alloy, (2) sustained stress in the ST direction and (3) ageing in a typical environment. If one of those conditions can be eliminated, this form of EAC cracking is unlikely to occur. The affected materials did pass the “state of the art” qualification requirements for mechanical and corrosion testing, but the current industry standard of testing for stress corrosion cracking (ASTM G47) is not capable of adequately detecting the risk of this form of EAC (see Note 1).

Note 1: The subject of this SIB is EAC caused by hydrogen assisted embrittlement resulting in a decrease of toughness but in absence of an obvious corrosion reaction (see Appendix 1 of this SIB, figure 5). It is different from classical stress corrosion cracking characterised by anodic dissolution with loss of material accompanied with findings of active corrosion like pitting or attack of grain boundaries (see Appendix 1 of this SIB, figure 6).

This is information only. Recommendations are not mandatory.



Sensitivity to this form of EAC has been confirmed for alloys 7037, 7040 (see Note 2), 7055, 7085, 7099, 7140, and 7449. Other alloys with similar compositions might also be affected. The material temper (i.e. the specified heat treatment and additional processing such as ageing and stress relief by stretching) and product form can also influence resistance to EAC

Note 2: Aluminium alloy 7040 has been found sensitive to this form of EAC in T7651 temper only. Other tempers commonly used with this alloy have not shown similar issue.

Occurrences of this form of EAC cannot be excluded in service and, if not detected, could lead to crack propagation, possibly resulting in reduced structural integrity. For specific designs that have already been identified, mandatory inspections and corrective actions have been initiated and further mandatory actions for other specific designs may follow.

EASA issued SIB 2018-04 to raise awareness, in all sectors of the industry, concerning this EAC phenomenon of these types of aluminium alloys. This SIB is revised to add aluminium alloy 7140 and to provide a generic test method that can be used to identify material susceptibility to this form of EAC.

Recommendation(s):

EASA recommends all affected organisations to evaluate the extent of the issue, particularly to:

- Identify components made of EAC sensitive aluminium alloys.
- Evaluate the sensitivity to and criticality of EAC in the component.
- Report these evaluation results to EASA.

In addition, EASA requests aluminium alloy producers to establish whether they supply any of the above mentioned alloys and, if so, to contact EASA and the relevant Design Approval Holder(s).

A generic test method that can be used to determine whether a material is potentially susceptible to EAC is provided in Appendix 1 of this revised SIB. This basic coupon test has been successfully used to confirm susceptibility to EAC in the alloys listed above when the recommendations for valid testing have been followed (see Appendix 1 of this SIB, paragraph 3). It may be useful to conduct comparative (control) testing in parallel with specimens of other alloys of known EAC performance. For a more detailed risk ranking, it may also be appropriate to define additional test specimens to represent product design details that are more representative of the structural configurations where the materials are used.

Contact(s):

For further information contact the EASA Safety Information Section, Certification Directorate.

E-mail: ADs@easa.europa.eu.

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Appendix 1 – EAC Generic Test Method

1. EAC generic test method and test conditions:

As suggested by public literature or published test methods:

Specimen:

- Specimen geometry: Round smooth bar → according to ASTM G 49 and ASTM E8 Tension test
- Align longitudinal axis of specimen (loading direction) with the Material S-T grain direction

Loading:

- Loading device: Test rig → In Style of ASTM G 49
- Loading: Constant load / displacement → according to ASTM G 49
- Load level: set at 85% Yield only → In the style ASTM G 64

Environment:

- Level of Humidity: 85% ± 5% → Ref. 1)
- Temperature: 70°C ± 1°C → Ref. 1)

Test time:

- Test duration is recommended to be at least 100 days

Reference 1: HYDROGEN ENVIRONMENT ASSISTED CRACKING OF AN AL-ZN-MG-(CU) ALLOY, George A. Young Jr., August 1999 (UMI Number: 9935089)

2. Definition of failure:

- A material is considered to have failed the test, and susceptible to EAC, if it shows cracking along the grain boundaries without corrosion attack or oxidation products on sample or fracture surface, as shown on the figures 1,3 and 5 below.
- If obvious through cracking has not occurred, a check for the presence of grain boundary cracking can be made by optical examination with magnification of at least 50x. Presence of grain boundary cracking is also considered a test failure.
- Specimen and fracture surface have to meet the validity requirements as given in Table 1 of this SIB. If the requirements are not met, the test is invalid and should be repeated.

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Table 1 – Test Validity Requirements

Observation	Requirement for a valid test
Evidence of the presence of condensation on specimen surfaces	Not allowed
Corrosion pitting or corrosion products on specimen surfaces (figures 2, 4 and 6)	Not allowed Surface of a failed sample by light microscopy, level of magnification: 50x Fracture surface and rim of fracture surface by Scanning Electron Microscopy, level of magnification: 2000x
Fracture surface morphology in the case of through fracture	Predominantly intergranular fracture path with little or no evidence of ductile decohesion (see figure 5) Level of magnification for examination by Scanning Electron Microscope: 6000x



3. Recommendations for ensuring a valid test:

- Careful extraction of the specimen from the plate material is required to ensure precise alignment of the S-T grain direction with the loading direction.
- After machining, the specimen surface must be cleaned to remove any greasy deposits (use ethanol, not acetone).
- During the time between specimen preparation and test start the specimen should not be exposed to an environment that can lead to condensation on the specimen surface. Storage and transport in a controlled environment is recommended.
- Galvanically decouple the loading clamps from the specimen and avoid trapping moisture between the clamps and specimen.
- Make sure that the test sample temperature is always above the dew point temperature to prevent condensation from forming on it. Allow time for the test sample to stabilize at the desired temperature before raising the humidity level.

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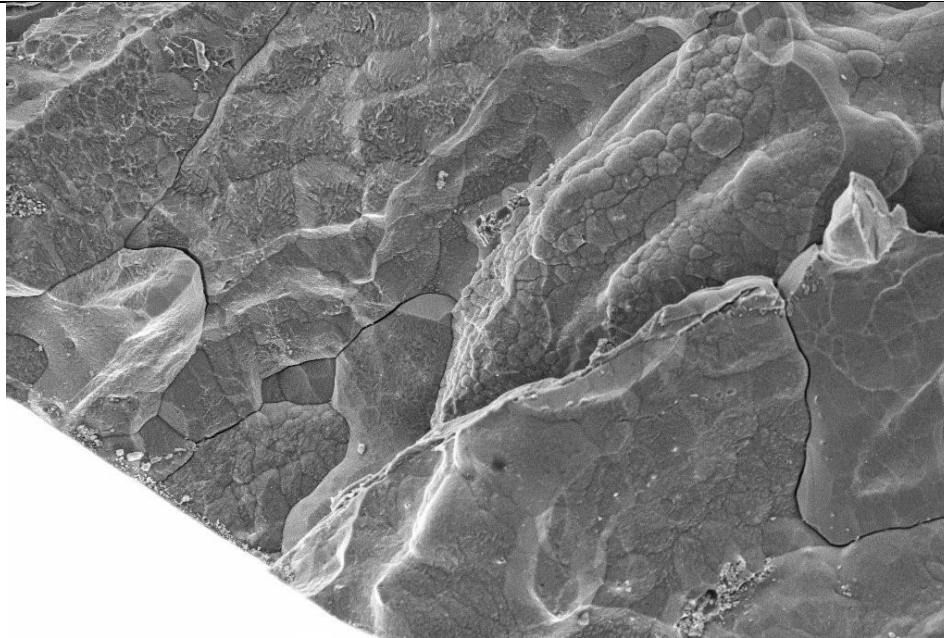
4. Examples for valid & non-valid tests

Valid test	Non-valid test due to condensation
 <p data-bbox="371 1169 891 1198">Figure 1 – Round smooth bar: not corroded</p>	 <p data-bbox="1379 1169 1850 1198">Figure 2 – Round smooth bar: corroded</p>

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Valid test

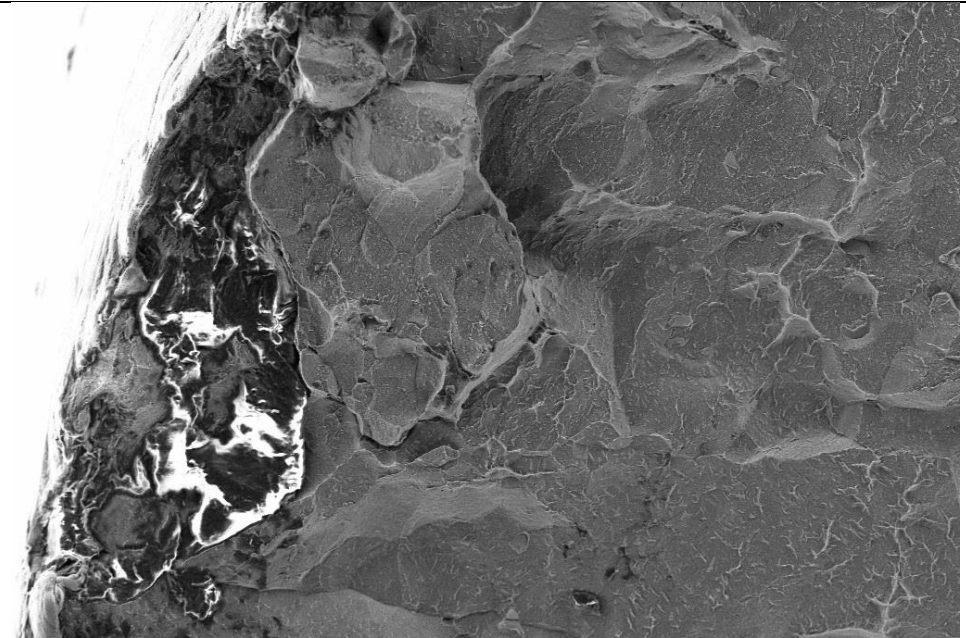


20 μ m

Only precipitates on the grain boundaries are visible

Figure 3 – Fracture surface without traces of corrosion

Non-valid test due to corrosion at initiation site



10 μ m

Precipitates & dark oxides on the grain boundaries are visible

Figure 4 – Fracture surface with traces of corrosion

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5. Difference between EAC & SCC test

EAC test

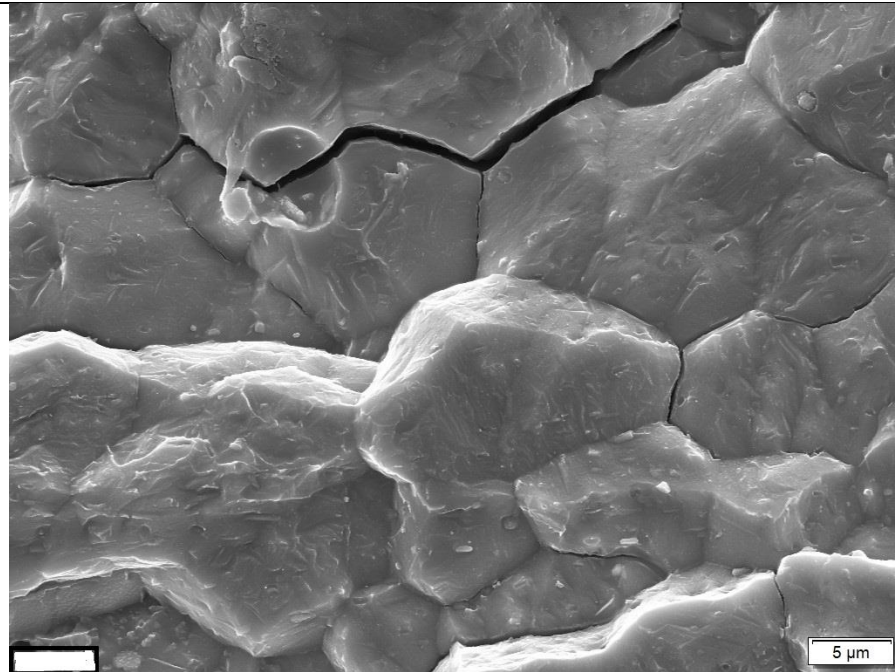


Figure 5 – Typical EAC fracture surface

SCC test (ASTM G 47)

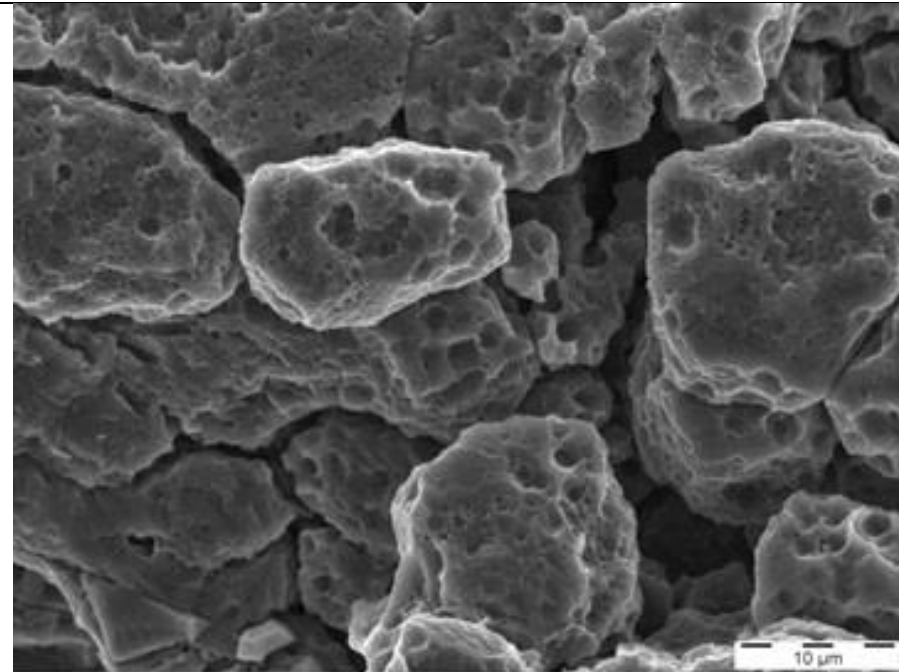


Figure 6 – Typical SCC fracture surface

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