# Humid Gas Stress Corrosion Cracking Test for Aluminum alloys

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16th November 2022

# Summary

- The experimental findings, underpinning the Material's Compatibility Test "Humid Gas Stress Corrosion Cracking Test for Aluminum alloys", is undeniably high-quality
- Few high-strength metallic alloys (Ferrous or non-ferrous) currently being used, in demanding structural engineering applications, will pass the proposed Humid Gas SCC Test
- The originator and a major contributor to the development of the ISO Sustained load cracking test methodology provides solid arguments why the proposed SCC Test:
  - Fails to provide the key information, cylinder designers, users and regulators seek
  - Is unrealistic and inappropriate
  - Should be replaced by an Alternative Test Method

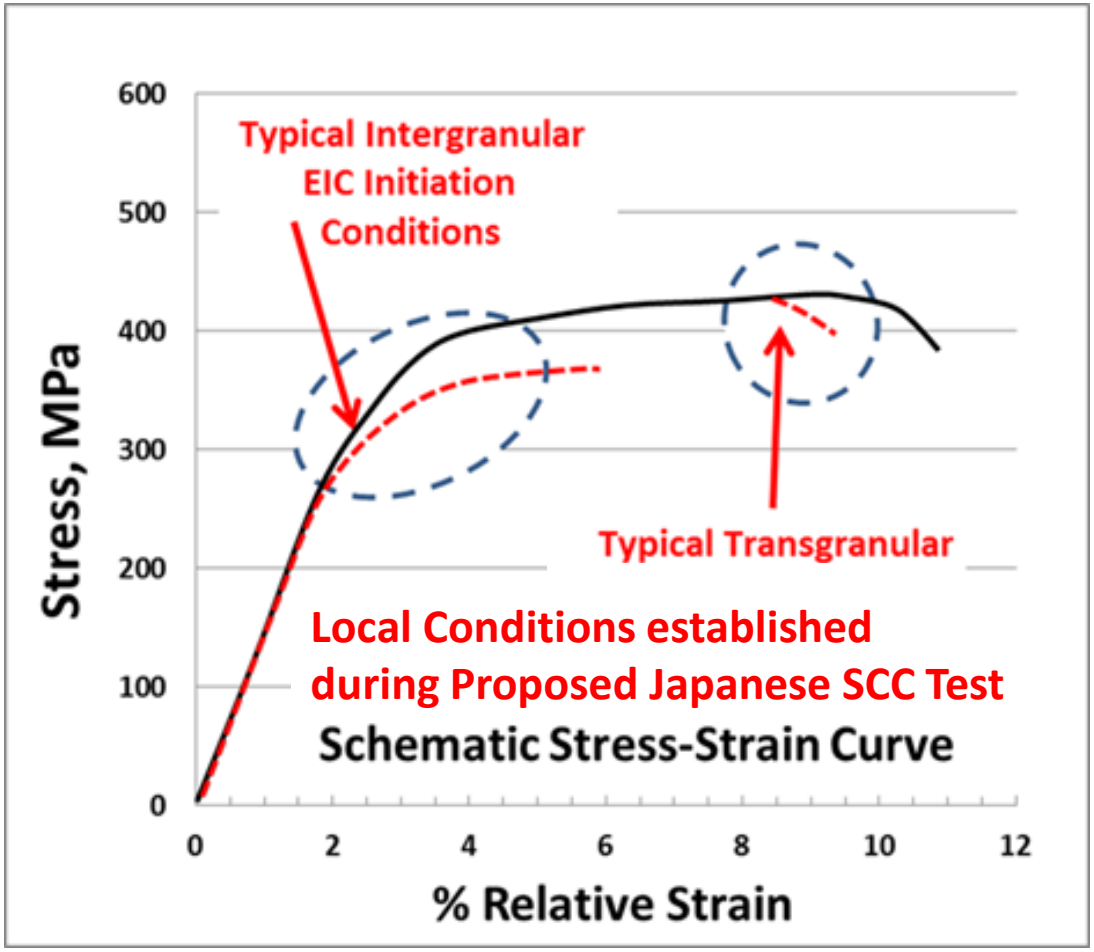
# Background

- >50 years experience indicates Commercial 6xxx series Al-Mg-Si alloys are '**practically immune**' to sub-critical cracking processes during their use in structural applications:
  - Stress Corrosion Cracking (SCC), hydrogen embrittlement (HE) and sustained load cracking (SLC)

# Japanese proposed
# Humid Gas Stress Corrosion Cracking Test

- Japanese research published over last decade or so confirms crack propagation rates for ‘long’ cracks in AA6061-T6 are enhanced by presence of moisture if mechanical driving forces are sufficiently high (Ogawa et al 2016, 2019)
- Please note: All aluminum alloys show crack growth rate enhancement in humid conditions when subjected to sufficient mechanical loading conditions (see next slide)

# Schematic showing loading conditions



# Can we provide an alternative Test Methodology?

- Yes
  - Alternate Test to provide quantitative information:
    - Demonstrating alloys tolerance of 'short' cracks (or other local stress raisers) is adequate to prevent stable SCC propagation under 'worst-case' service conditions, and
    - For use in structural design and service-life prediction
  - Dr Holroyd proposes to customize SCC test development for high-pressure Aluminum all-metal and composite pressure containers.
  - Secondary testing, providing confidence in the alternative test, to be conducted using the OICA proposed test but reducing the initial mechanical loading conditions from ~85% $K_{IC}$ to levels just above the alternate test threshold.

# HH Refereed publications in Journals and Book Chapters on Aluminum alloys include > 50 on SCC and >10 on SLC.

**Selecting one/two a decade**

**1979**. "Reduced Ductility of a High Strength Aluminium Alloy During and After Exposure to Water",
D. Hardie, N.J.H. Holroyd and R.N. Parkins, Metal Science.

**1987.** "Effects of Lead on the Sustained-Load Cracking of Al-Mg-Si Alloys at Ambient Temperatures",
J.J. Lewandowski, V. Kohler and N.J.H. Holroyd, Materials Science and Engineering.

**1992.** "Strain Concentration at Grain Boundaries in Al-Mg-Si Alloys",
P.M. Singh, J.T. Evans and N.J.H. Holroyd, Materials Science & Engineering.

**2001**. "Environmental Effects on Aluminium Alloys",
N J H Holroyd, Invited chapter in "Environment Effects on Engineered Materials", Elsevier, pp 173-251.

**2010.** "Technical Basis for Acceptance/Rejection Criteria for Flaws in High Pressure Gas Cylinders",
M Rana, J Smith and N J H Holroyd, J. Pressure Vessel Technology.

**2011.** "Crack Propagation during Sustained-Load Cracking of Al-Zn-Mg-Cu alloys exposed to Moist Air or Distilled Water",
N J H Holroyd and G M Scamans, Metall. and Mater. Trans. A.

**2019**. "Evaluation of Environment-induced cracking in commercial aluminum alloys: Crack arrest or growth",
N. J. H. Holroyd, Plenary Lecture at LightMat, 3rd Conference and Exhibition on Light Metals – Science and Technology.

**2022**. "Environment-Induced Cracking of High-Strength Al-Zn-Mg-Cu Aluminum Alloys - Past, Present and Future,
N J Henry Holroyd, T L Burnett, J J Lewandowski and G M. Scamans, Corrosion, Published on-line, 27th October .

# Thank you