HG-SCC test method for aluminium alloy

- Disclosure : Full text of HG-SCC test method as HPI standard
- Introduction : Japanese test data under humid gas environment

HG-SCC : **H**umid **G**as **S**tress **C**orrosion **C**racking
HPI : **H**igh **P**ressure **I**nstitute of Japan

Transmitted by JAPAN

GTR13 Phase2 Informal WG #2 : 5-7/Feb/2018 @Torrance,CA,USA

Why HG-SCC test method is necessary?

Last Informal WG (Oct/2017)
GTR13-1-07

- Therefore, when applying aluminum alloys to CHSS, As one of the material requirements, stress corrosion cracking under humid gas environment should be considered.
- The HG-SCC test method was discussed in Japan and will be published in February 2018 as HPI standard.
- Also, this HG-SCC test method is quoted in SAE J 2579.

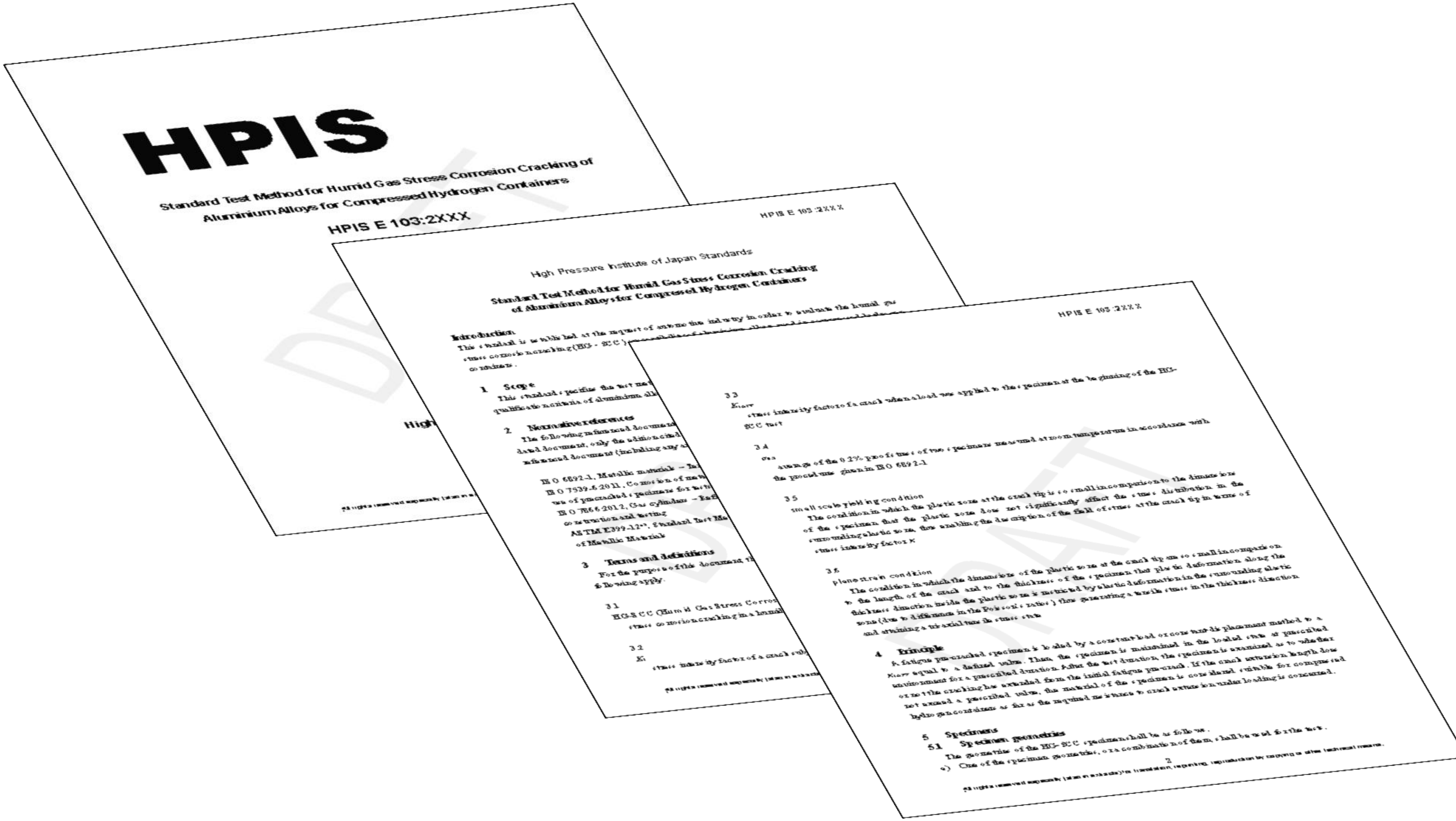
↓

Today, I will present outline of "HG-SCC test methods for aluminum alloys "

Unfortunately, until February 2018, it is difficult to disclose the full text of the HG-SCC test method. I would like to focus on the summary today.

The "HG-SCC test method" was introduced at the last IWG.
At this IWG → ■ Disclosure of the full text of HG-SCC test method
■ Introduction of Japanese test data under humid gas environment

■Disclosure of the full text of HG-SCC test method



In order to standardize the HG-SCC test method,
HPI disclosed the draft and solicited public comments in Dec/2017.
The draft is uploaded as IWG document. (see Appendix for details)

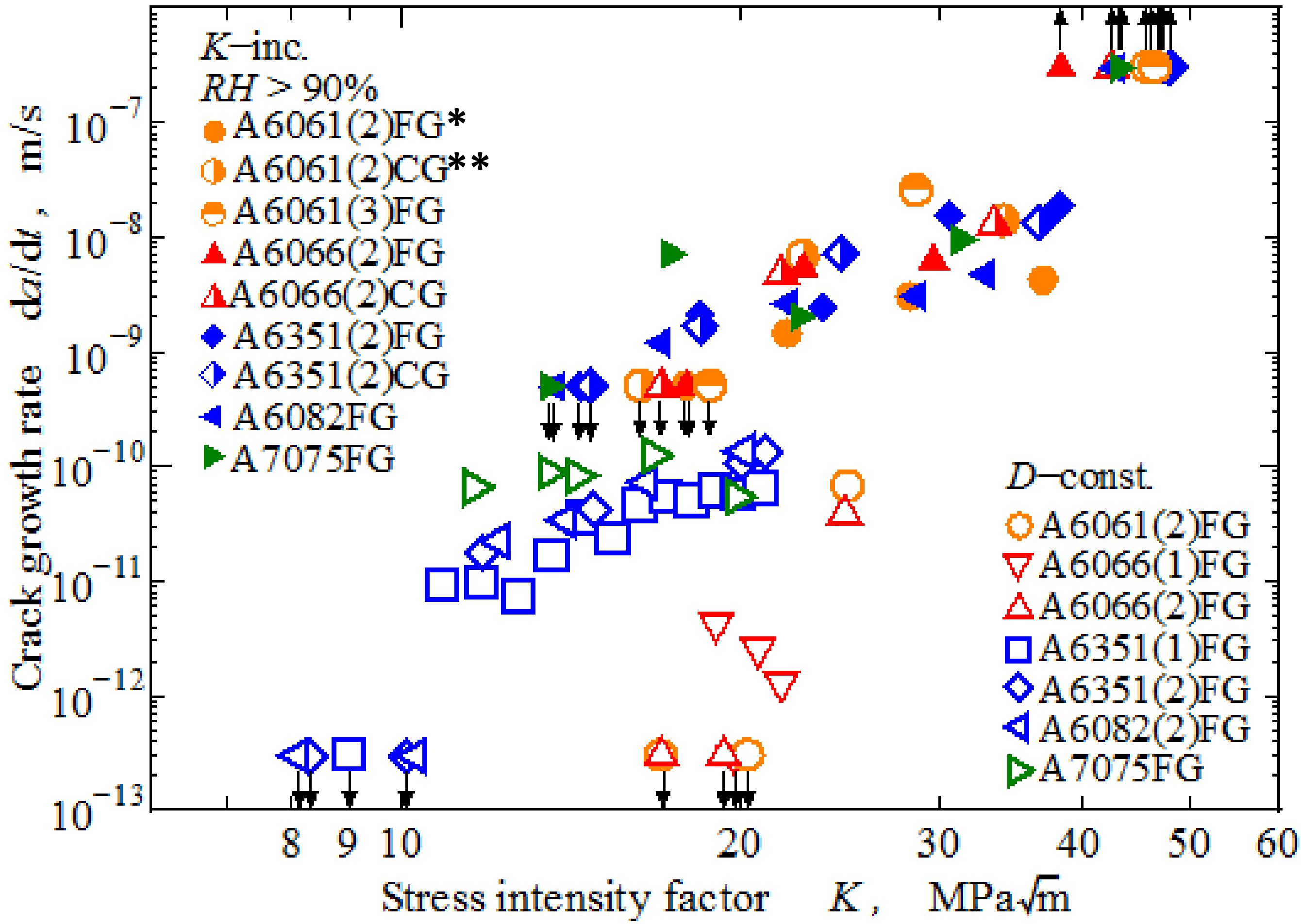
■Japanese test data under humid gas environment

In addition to the disclosure of the HG-SCC test method draft, Japanese NEDO project has some of aluminium alloy’s data under humid gas environments.

(1) Basic property test on stress corrosion cracking of aluminium alloys under humid gas environment
https://doi.org/10.11181/hpi.54.277

(2) HG-SCC test result by main chemical content (Cu content)

■ Basic property test on stress corrosion cracking

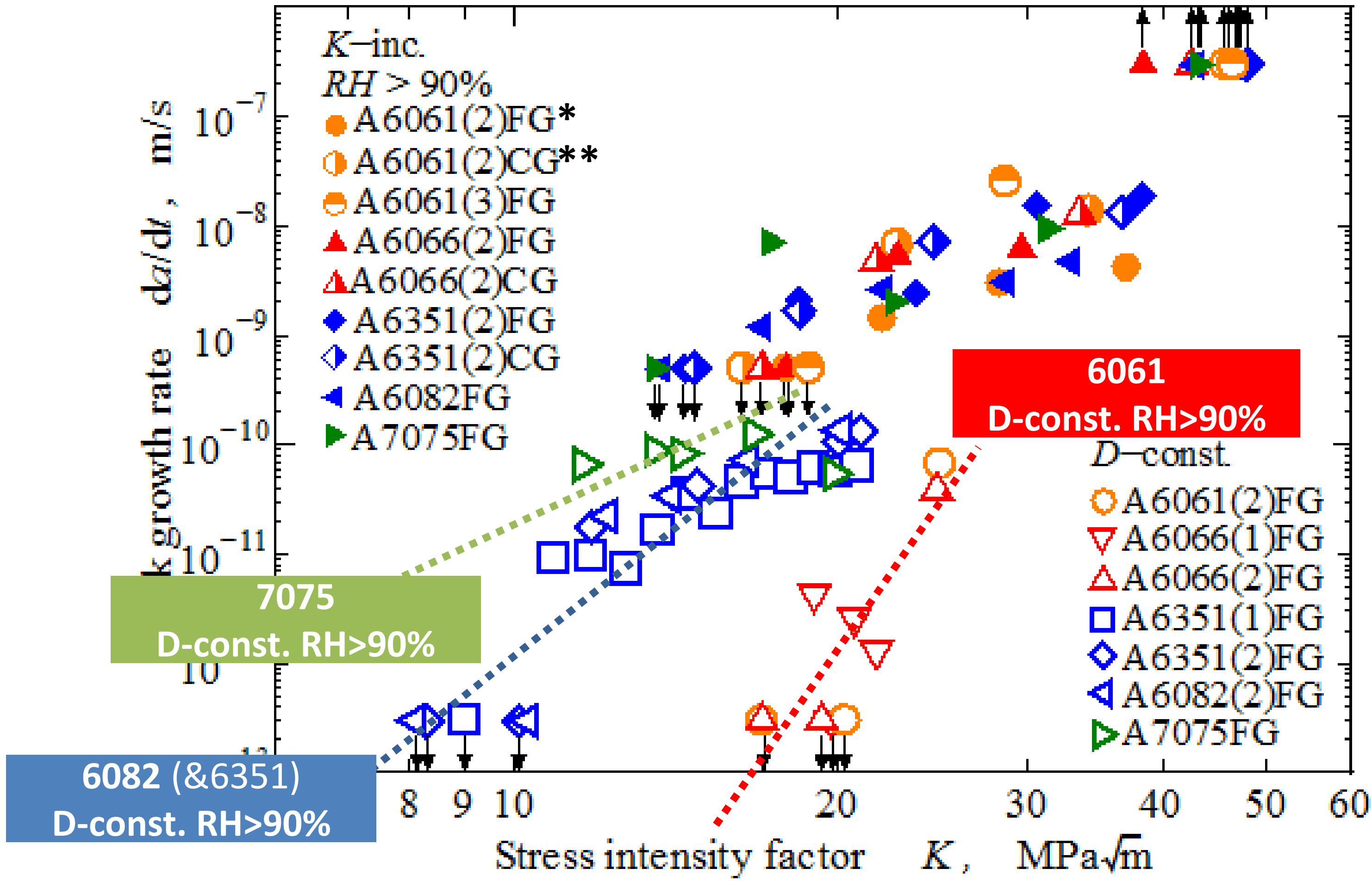


FG *
Fine Grain
CG **
Coarse Grain

Fig.2 SCC characteristics of the standard alloys.

Test method & data of A6061,A6066,A6351	**Study on Evaluation Methods for Stress Corrosion Cracking and Fatigue Crack Growth of Aluminum Alloys for Hydrogen Containers** (Takesshi Ogawa et al ; JHPI Vol.54 No.6 2016 : http://doi.org/10.11181/hpi.54.277)
Data of A6082,A7075	**Effect of Chemical Composition on the Characteristics of Humid Gas Stress Corrosion Cracking of Al-Mg-Si Alloys** (S.Hirano et al ; JSME Kanto Annual meeting @March 16, 2017 – Paper OS0501-04)

■ Basic property test on stress corrosion cracking



FG *
Fine Grain
CG **
Coarse Grain

Fig.2 SCC characteristics of the standard alloys.

There are aluminium alloys that are susceptible to stress corrosion cracking under humid gas environment, so it is necessary to determine material requirements when used as CHSS material.

■Japanese test data under humid gas environment

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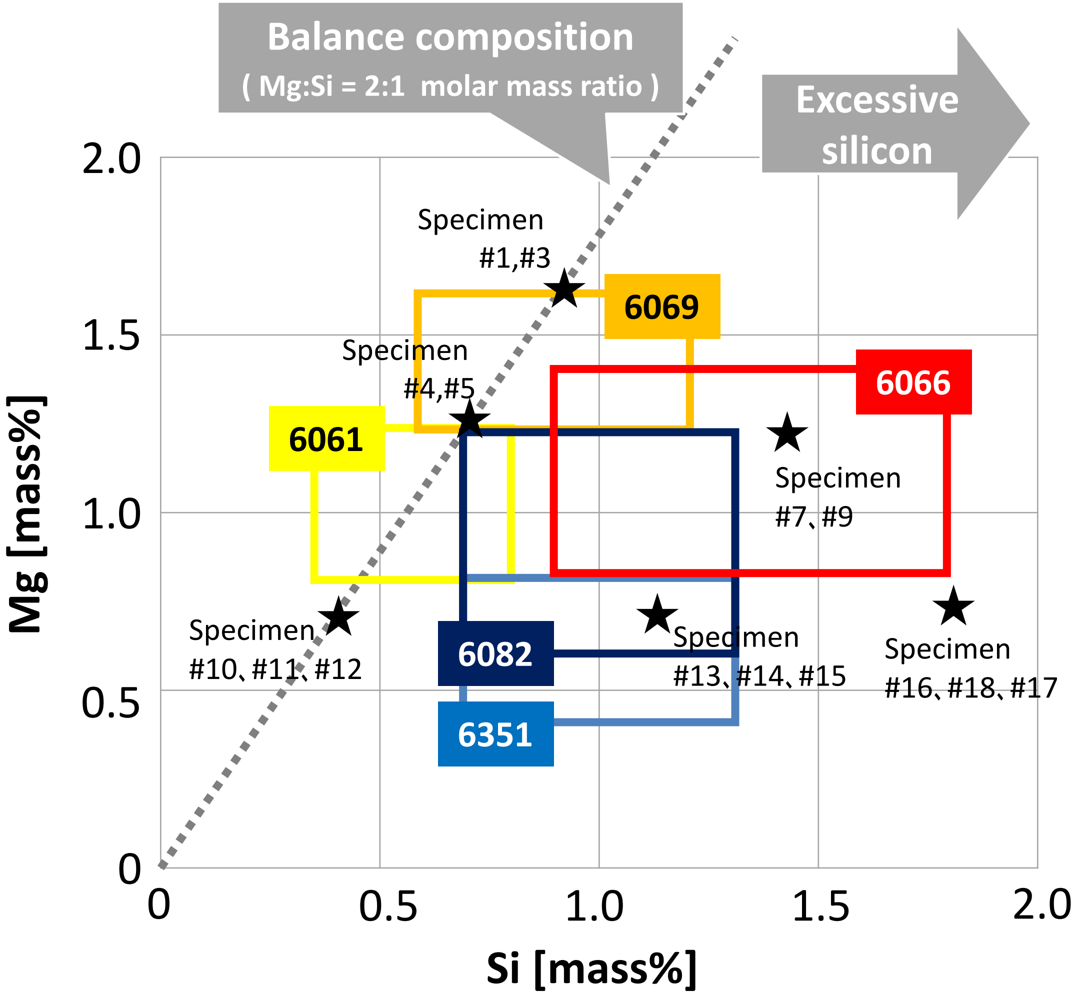
(2) HG-SCC test result by main chemical content (Cu content)

■HG-SCC test result by main chemical content (Cu content)



Specimen Group	Cu Content %
Specimen #1, #4, #7, #10, #13, #16	0.0
Specimen #5, #11, #14, #18	0.3
Specimen #3, #9, #12, #15, #17	1.0

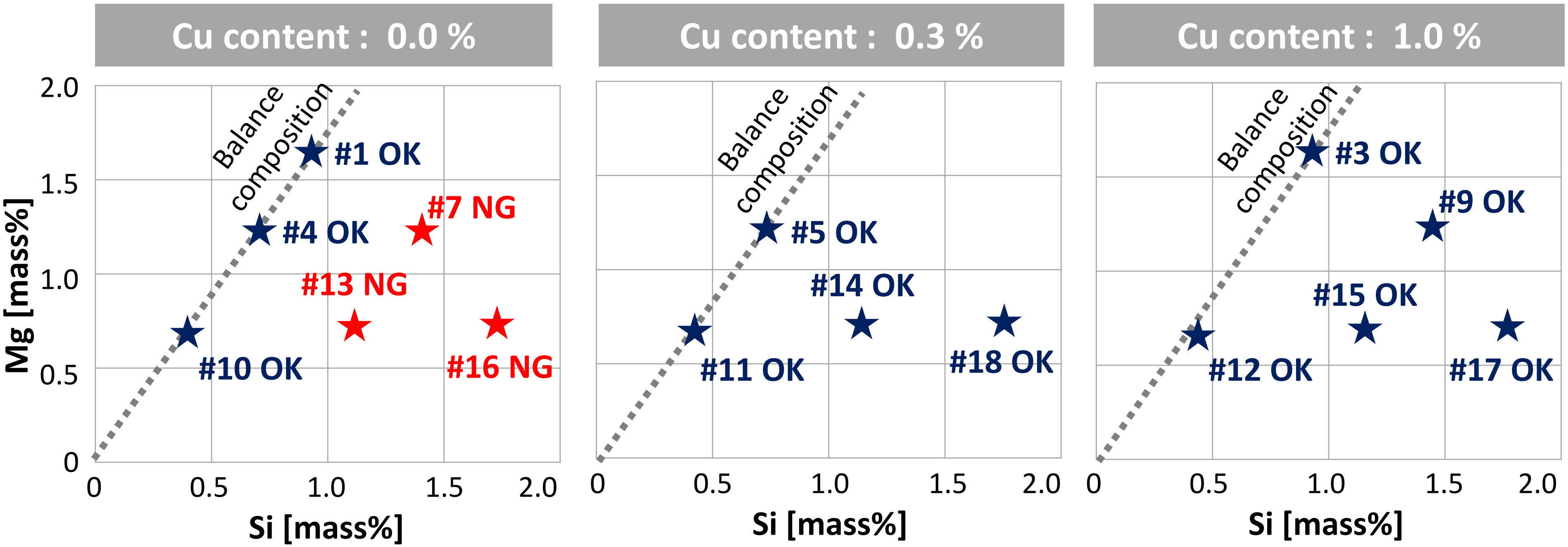
Standard alloy	Cu content %
6061	0.15 – 0.40
6066	0.7 – 1.2
6069	0.55 – 1.0
6351	≤ 0.01
6082	≤ 0.01

In the Japanese NEDO project, in order to investigate the effect of the HG-SCC characteristics on the material chemical composition, the above aluminium alloy was prepared and the HG-SCC test was carried out.
(This example uses copper content as a parameter)

■ HG-SCC test result by main chemical content (Cu content)

Result of HG-SCC Test by main chemical content (Cu)

- Test condition： 25 ° C, RH85 %, 90 days
- Qualification ： The crack extension is examined to exceed 0.16 mm or not.



- ■ Aluminium alloy of balanced composition has good HG-SCC characteristics and is suitable as a material of CHSS.
- ■ Aluminium alloy having an excessive silicon has poor HG-SCC characteristics.

Appendix

In order to standardize the HG-SCC test method,
HPI disclosed the draft and solicited public comments in December 2017.
In this Appendix, the full text of the HG-SCC test method will be posted.

HG-SCC : **H**umid **G**as **S**tress **C**orrosion **C**racking
HPI : **H**igh **P**ressure **I**nstitute of Japan

HPIS

Standard Test Method for Humid Gas Stress Corrosion Cracking of Aluminium Alloys for Compressed Hydrogen Containers

HPIS E 103:2XXX

XXX.XX.2XXX

High Pressure Institute of Japan

Contents

High Pressure Institute of Japan Standards

Standard Test Method for Humid Gas Stress Corrosion Cracking of Aluminium Alloys for Compressed Hydrogen Containers

Introduction

This standard is established at the request of automotive industry in order to evaluate the humid gas stress corrosion cracking (HG - SCC) susceptibility of aluminium alloys used in compressed hydrogen containers.

1 Scope

This standard specifies the test method for humid gas stress corrosion cracking (HG-SCC) and the qualification criteria of aluminium alloys for compressed hydrogen containers for automotive use.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated document, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6892-1, Metallic materials – Tensile testing – Part 1: Method of test at room temperature

ISO 7539-6:2011, Corrosion of metals and alloys – Stress corrosion testing – Part 6: Preparation and use of precracked specimens for tests under constant load or constant displacement

ISO 7866:2012, Gas cylinders – Refillable seamless aluminium alloy gas cylinders – Design, construction and testing

ASTM E399-12^{e2}, Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

3 Terms and definitions

For the purpose of this document, the terms and definitions given in **ISO 7539-6**:2011 and the following apply.

3.1

HG-SCC (Humid Gas Stress Corrosion Cracking)

stress corrosion cracking in a humid gas environment

3.2

$\boldsymbol{K_{\mathrm{I}}}$

stress intensity factor of a crack subjected to opening mode displacements (mode I)

3.3

***K*IAPP**

stress intensity factor of a crack when a load was applied to the specimen at the beginning of the HG-SCC test

3.4

$\sigma_{0.2}$

average of the 0.2% proof stress of two specimens measured at room temperature in accordance with the procedures given in **ISO 6892-1**

3.5

small scale yielding condition

The condition in which the plastic zone at the crack tip is so small in comparison to the dimensions of the specimen that the plastic zone does not significantly affect the stress distribution in the surrounding elastic zone, thus enabling the description of the field of stress at the crack tip in terms of stress intensity factor *K*

3.6

plane strain condition

The condition in which the dimensions of the plastic zone at the crack tip are so small in comparison to the length of the crack and to the thickness of the specimen that plastic deformation along the thickness direction inside the plastic zone is restricted by elastic deformation in the surrounding elastic zone (due to difference in the Poisson's ratios), thus generating a tensile stress in the thickness direction and attaining a tri-axial tensile stress state

4 Principle

A fatigue pre-cracked specimen is loaded by a constant-load or constant-displacement method to a K_{IAPP} equal to a defined value. Then, the specimen is maintained in the loaded state at prescribed environment for a prescribed duration. After the test duration, the specimen is examined as to whether or not the cracking has extended from the initial fatigue pre-crack. If the crack extension length does not exceed a prescribed value, the material of the specimen is considered suitable for compressed hydrogen containers as far as the required resistance to crack extension under loading is concerned.

5 Specimens

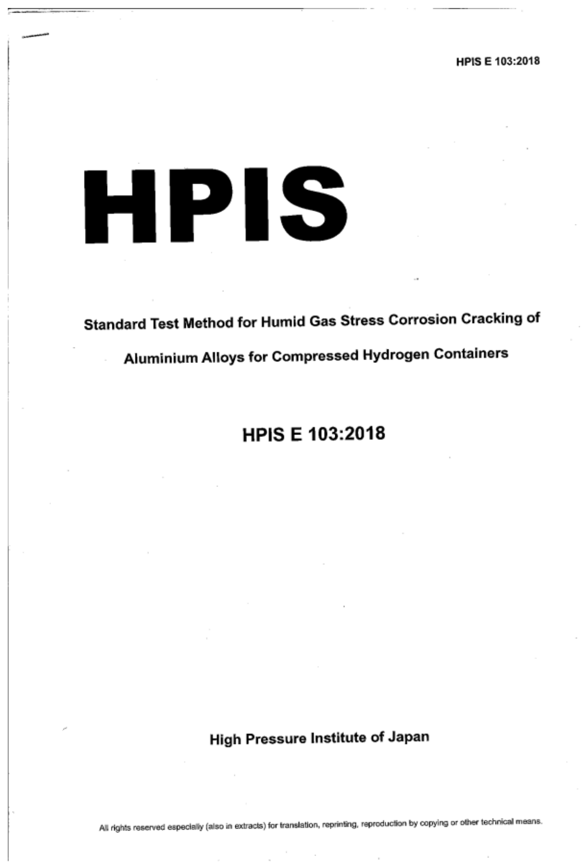
5.1 Specimen geometries

The geometries of the HG-SCC specimen shall be as follows.

a) One of the specimen geometries, or a combination of them, shall be used for the tests.

Appendix

Afterwards, The HG-SCC test method was officially published as HPIS E 103: 2018. Please refer to the official version for details.



HPIS E 103:2018

HPIS

Standard Test Method for Humid Gas Stress Corrosion Cracking of Aluminium Alloys for Compressed Hydrogen Containers

HPIS E 103:2018

High Pressure Institute of Japan

http://www.hpij.org/publication/?action=common_download_main&upload_id=1946