Jan. 25. 2023

UN R134 Material Compatibility Issue
(Concerns from material experts in Japan)

Transmitted by Japan

Alternative proposal from OICA

- **Excerpt from Informal document GRSP-72-17**

6.3. Material compatibility

The materials used for TPRD, check valve and shut-off valve shall be compatible with hydrogen when they are in contact with hydrogen in liquid and/or gaseous state and if a failure of a part of the component leads to a leakage. Incompatible materials shall not be in contact with each other.

The manufacturer shall provide the documentation justifying that the materials used in the specific component submitted for approval in accordance with Part II of this Regulation, comply with the applicable requirements specified in paragraph 6.3.1. This requirement does not apply to materials that do not come in contact with hydrogen under normal conditions.

6.3.1. Metallic materials

Metallic materials used for TPRD, check valve and shut-off valve shall be evaluated in accordance with Annex 8 of this Regulation.

[Alternatively, if pressure cycling tests specified in paragraphs 6.1(a) and 6.2(c), are passed according to the requirements using hydrogen gas, then the material compatibility test in Annex 8 Part 1 is deemed to be met for the tested component design.]

Pressure cycling test in hydrogen gas using actual component

Background understanding of OICA's proposal

- **Understanding about OICA's proposal**
  - The material test method which has been proposed for GTR13 Phase 2 has stricter load conditions than the stress conditions applied to actual components, and there are few commercial test laboratories that can carry out the tests. (no test laboratories in Europe)
  - It is acceptable to describe it as a reference test in GTR13, but it is problematic to use it as a mandate in UN R134.

We can understand this situation, especially problem of lack of test laboratories, but .....

Test condition comparison

- **OICA's proposal**
  - 6.1(a) Pressure cycling test for TPRD :
    - ✓ Total 15,000 cycles
      (including 10,000 cycles at 20℃, 2MPa to 125%NWP)
  - 6.2(c) Extreme temperature pressure cycling test for Check valve、Shut-off valve :
    - ✓ Total 15,000 cycles for Check valve
      (including 13,500 cycles at 20℃, 100%NWP)
    - ✓ Total 50,000 cycles for Shut-off valve
      (including 45,000 cycles at 20℃, 100%NWP)

Big difference between both number of cycles

- **The material compatibility test in draft UN R134, Annex 8 Part 1**
  - ✓ Option 1) Notched fatigue life test : 100,000 cycles at 20℃
  - ✓ Option 2) SSRT test : Yield strength > 0.80 yield strength in air
    @The strain rate ≤ 5×10^{-5} s^{-1} at -45℃
    Smooth fatigue life test : 200,000 cycles at 20℃

Basic concept of material test method in Annex 8, Part 1

Basic concept based on the GTR No.13 Phase 2 discussion

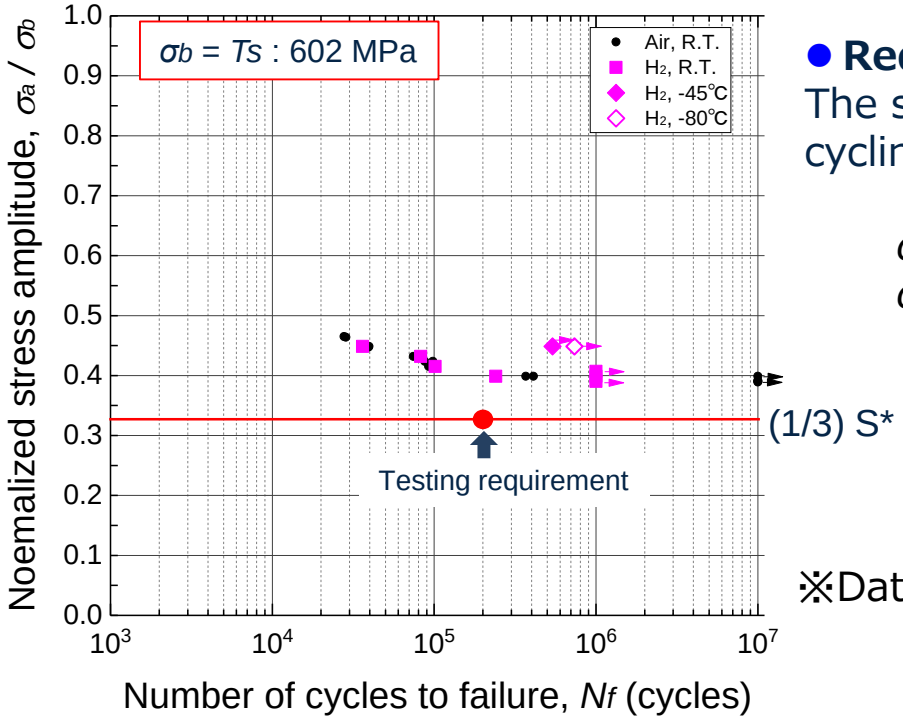
- It is not possible to uniformly evaluate the material compatibility on a part-by-part basis, because the load conditions inside the component would change depending on the part's usage environment, usage conditions, processing conditions, part shape, and so on.

- This material test method is intended to guarantee the infinite life of components from the material point of view, regardless of the above environmental conditions.
  (The designer (manufacturer) should ultimately judge the functional safety of the component.)

Guarantee of the infinite life of components

Explanation based on the material evaluation

Example) SUS316 *P-S-N* diagram



● **Requirement for fatigue life test of Option 2**
The stress at maximum load during fatigue cycling shall be greater than or equal to 1/3 of S*

σ_a : Stress amplitude
σ_b = Ts : certified (mill sheet) tensile strength at R.T. in air
≒ S* : the average tensile strength measured at R.T. in air

※Data provided by NEDO project

Passing this test means that an infinite life design is guaranteed in any environmental conditions within the elastic range.

Concerns about OICA's proposal

Concerns

- It seems that the number of cycling test in OICA's proposal was set for the operation test of each component, not for fatigue life evaluation.
  - This test cannot guarantee an infinite life of the components.
  - Any material can pass this test, and materials that do not satisfy hydrogen compatibility may flow into the market.

Japanese stakeholders (government, technical organizations, experts, etc.) cannot accept OICA's proposal as long as the above concerns remain.
(In particular, these concerns are based on the strong opinions of Japanese material experts.)

Suggestion for conducting the material testing

The material compatibility test

- As you know, there are 2 kinds of options in the material compatibility test in Annex 8, Part 1.
  Option 1) Notched fatigue life test (R=0.1) : 100,000 cycles at 20℃
  Option 2) Smooth fatigue life test (R=-1): 200,000 cycles at 20℃
  also required SSRT test at -45℃

- Option 1 is easier to conduct than Option 2. Because only the tension-tension (R=0.1) fatigue life test at R.T with notched specimen is required in Option 1.
  Instead, the tension-compression (R=-1) fatigue life test at R.T with smooth specimen and SSRT test at low temperature are required in Option 2. These are little bit difficult to conduct.

We recommend to conduct the material compatibility test by Option 1.
Ref.) If any, we can introduce the commercial test laboratory in Japan.