# COMPARISON OF REGULATIONS CODES AND STANDARDS FOR HYDROGEN REFUELING STATIONS IN JAPAN AND FRANCE

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**ABSTRACT**
The states of Regulations Codes and Standards (RCS) of hydrogen refueling stations (HRSs) in Japan and France are compared and specified items to understand correspondence and differences among each RCSs for realizing harmonization in RCS. Japan has been trying to reform its RCSs to reduce HRS installation and operation costs as a governmental target. Specific crucial regulatory items such as safety distances, mitigation means, materials for hydrogen storage and certification of anti-explosion proof equipments are compared in order to identify the origins of the current obstacles for disseminating HRS.

## 1 INTRODUCTION

In order to accelerate the expansion of hydrogen refueling stations worldwide harmonization in RCS is essential. Nowadays, regulations are defined country by country hence the official requirements are extremely different from a geography to another one. A state of the art analysis on existing regulations in Japan and France is performed to shed light on the most crucial points. Special attention is paid to separation and safety distances, mitigations means, e.g. detection, protective walls, explosion panels and materials used for hydrogen storage and certification of anti-explosion proof equipments.

## 2 OVERVIEW OF THE JAPANESE AND FRENCH REGULATIONS

The states of regulations related to HRS for Japan and France are explained with current topics.

### 2.1 Japan

*2.1.1 Current regulation*

To install HRS in Japan, many regulations about the construction/material/operation force installers to apply expensive and time consuming procedures. The Ministry of Economy, Trade and Industry (METI) of Japan has preceded to legislative simplifications to promote the introduction of HRS in Japan and especially, to spread Fuel Cell Vehicle (FCV) widely throughout the whole country.

However, these efforts are not enough for economical acceptable of HRS by the Japanese market.

METI has promoted simplification of regulations for HRS to enhance a wide installation of HRS in Japan by reviewing the current regulations technically and legally.

*2.1.2 Regulatory reforms of HRS in Japan*

From 2013, the Cabinet Office of Japan (CAO) has promoted the “Regulatory Reform” to re-construct Japanese economical society to prevent from catching up the global status by strict and complex legal restrictions. To perform these reforms, the CAO has established “Regulatory Reform Promotion Council” for managing. The significance of the reform is listed below:

1. Enhancing innovation catching up change of economic environment
2. Increasing choice of new products and services
3. Increasing productivity of companies by using their original ideas with improved environment
4. Preparing system supporting variation work styles and labor mobility
5. Removing problems inhibiting activation of local economies

The regulatory reform of HRS is one of the items from the beginning. The reform elements are listed each fiscal year and group of such elements is-called “round”. The items for HRS were listed in the 1st, 3rd, and 5th rounds in 2013, 2015, and 2017 FY, respectively.

Table 1 shows the items of the regulatory reform for HRS in the 5th round released in 2017 FY [1]. All 20 items are classified into “construction” or “operation”, directly related to CAPEX and OPEX. Each item is first discussed in “public hearing” held by METI with associated reform plans submitted by different organizations (e.g. The High Pressure Gas Safety Institute of Japan (KHK) or Japan Petroleum Energy Center (JPEC) etc.) and industrial groups for “consideration” of the problems for realizing ideas in each items. After reaching consensus, actual legal requirement for “legislation” is considered. Finally, the corresponding laws or ministerial ordinances are revised for execution.

Table 1 Items of regulatory reform for HRS in 5th round released in 2017FY and status of consideration and legislation in August 2018

| No. | Influence on: | Item | Proposal | Consideration | Legislation |
|---|---|---|---|---|---|
| 1 | Operation | Security register | Abolish | F | NF |
| 2 | Operation | Store manager | Abolish | F | NF |
| 3 | Operation | Confirmation of FCV’s tank voucher | Abolish | NF | NF |
| 4 | Operation | Trace leakage of H2 as accident | Mitigate the definition of leakage | NF | NF |
| 5 | Construction | Shield for containers | Abolish by notification to prefectural office | F | F |
| 6 | Operation | 1 month approval for spare parts | Abolish | Partly F | Partly F |
| 7 | Construction | Sprinkler | Abolish | F | F |
| 8 | Operation | Periodical inspection | Legislate | NF | NF |
| 9 | Operation | Managing safety of customer | Abolish | NF | NF |
| 10 | Operation | Unmanned operation | Legislate | NF | NF |
| 11 | Operation | Supervising multiple HRSs | Legislate | NF | NF |
| 12 | Operation | Requirements for safety supervisor | Mitigate | NF | NF |
| 13 | Operation | Installation of LH2 HRS | Revise laws | F | F |
| 14 | Operation | Safety supervision of HFS | Mitigate to be same as HRS | NF | NF |
| 15 | Construction | Risk assessment for mitigating HRS | Perform | NF | NF |
| 16 | Construction | Materials for HRS | Mitigate | NF | NF |
| 17 | Construction | Pressure restriction for SF3.5 design | Abolish | NF | NF |
| 18 | Construction | Duplicated inspections | Abolish domestic inspection | NF | NF |
| 19 | Construction | Restriction on max. temperature of bundles | Abolish | F | (no need) |
| 20 | Construction | SF less than 3.5 | Revise laws | NF | NF |

F: Finished, NF: Not Finished

### 2.2 France

(Details to be shown in the presentation)

## 3 COMPARISONS OF REGULATIONS

### 3.1 Safety distance and mitigation means

Table 2 shows regulations for safety distances and protection barriers of HRS in Japan. Table 2 also displays the comparison of Japanese regulations with the French ones. The safety distance from HRS boundary in Japan is larger than the French one. Instead of keeping much larger distance between HRS equipment and boundary, installation of protection barriers is legally acceptable in both Japan and France. However, the Japanese regulation requires that the height of the barrier must be larger or equal to the original safety distance (Fig. 1). This regulation forces HRS manufacturers to build much taller barrier compared to France, at an additional cost.

Another regulation specific to Japan is the obligation to install walls between hydrogen containing equipment at the HRS site. This requirement aims at preventing any “domino effect” in hydrogen explosions. In France, such requirements on “domino effects” are not considered.

Recommendations and timelines:

The definition of safety distance should be changed to be that the distance between HRS equipment and an adjacent building is considered. The earlier realization is desirable.

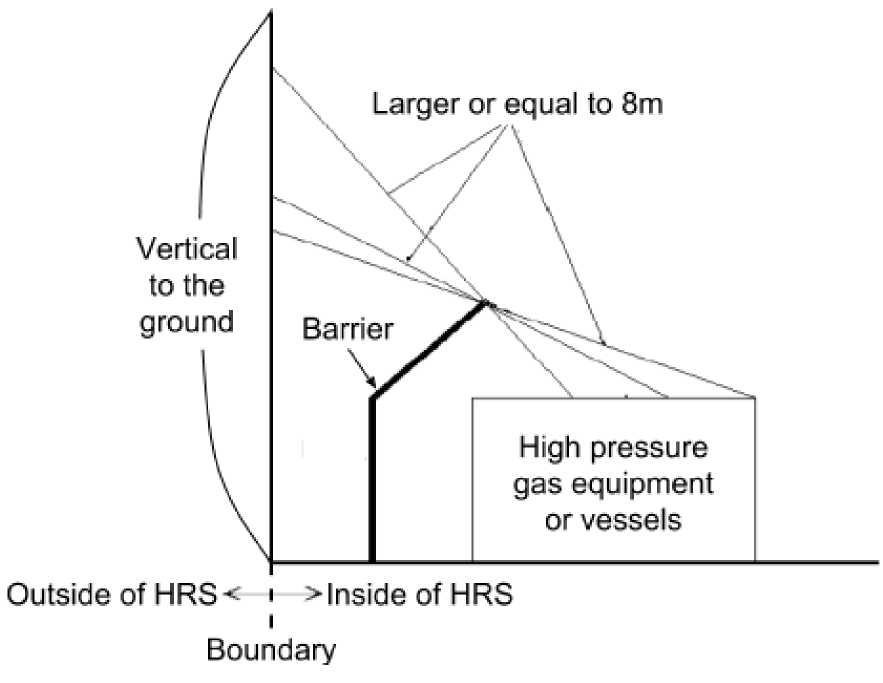


Figure 1 Japanese definition of safety distance between high pressure gas facility and boundary with barrier

Table 2 Regulations for safety distance and protection barrier of HRS in Japan and in France

<table>
<tr><th colspan="3"></th><th>Japan</th><th>France</th></tr>
<tr><td>Safety distance to the site frontier</td><td colspan="2">From high pressure gas equipment, or From vessels</td><td>8m (or install barrier)<br>6m (for less than/equal to 40MPa, or install barrier)</td><td>12 m for a maximum supply of 120g/s<br>10m for a max supply of 120g/s and an automatic valve closure in less than 2 sec<br>10 m for a max supply of 60g/s<br>8 m for a max supply of 60g/s and an automatic valve closure in less than 2 sec<br>6m for a max supply of 20g/s<br>OR to install a fire resistant wall</td></tr>
<tr><td>Safety distance to inhabited facility/parking space</td><td colspan="2">From dispenser</td><td>-<br>(8m required as anti-explosion proof equipment)<br>(60cm for prefectures accepting JPEC-S0004 standard)</td><td>5m</td></tr>
<tr><td rowspan="4">Protection Barrier</td><td colspan="2">Combination requiring installation<br>(Y: necessary / N: not necessary)<br>(Red: Japan / Blue: France)</td><td colspan="2">
<table>
<tr><td></td><td colspan="5">HRS equipment</td><td>Frontier</td></tr>
<tr><td rowspan="5">HRS equipment</td><td></td><td>Trailer</td><td>Compressor</td><td>Accumulator</td><td>Dispenser</td><td></td></tr>
<tr><td>Trailer</td><td></td><td>N</td><td>N</td><td>N</td><td>Y</td></tr>
<tr><td>Compressor</td><td>N</td><td></td><td>N</td><td>N</td><td>Y</td></tr>
<tr><td>Accumulator</td><td>N</td><td>Y</td><td></td><td>N</td><td>Y</td></tr>
<tr><td>Dispenser</td><td>N</td><td>Y</td><td>Y</td><td></td><td>Y</td></tr>
<tr><td colspan="2">Frontier</td><td>Y</td><td>Y</td><td>Y</td><td>Y</td><td></td></tr>
</table>
</td></tr>
<tr><td rowspan="2">Height</td><td>Between HRS equipment</td><td>2m</td><td>Not Necessary</td></tr>
<tr><td>At frontier</td><td>Enough height to satisfy the safety distance regardless of condition (vacant/something built) beside HRS frontier.</td><td>At least 3m and 0.5m taller than the highest point in distribution area)</td></tr>
<tr><td colspan="2">Material</td><td>Reinforced-concrete (thickness: 12cm ~) or<br>Concrete block (thickness: 15cm ~) or<br>Steel (thickness: 6mm ~)</td><td>(Simple wall satisfying REI120 of European fire resistance class)</td></tr>
<tr><td colspan="3">Fire wall</td><td>Necessary<br>(around HRS, height: 2m, replaceable by barrier)</td><td>Not Necessary</td></tr>
</table>

### 3.2 Selection of material for hydrogen storage

In Japan, HRS materials for hydrogen transport and storage should comply with the regulation of the Exemplified Standards of the Regulation on Safety of General High Pressure Gas (GHPGSR). It defines the acceptable materials by the number of 'Nickel equivalence' (Ni eq.) calculated from atomic composition, because it is known that a larger nickel content of austenite stainless steel increases the durability for hydrogen embrittlement. Also each Ni eq. values are classified according to 3 temperature ranges. In France, as an example of an EU case, HRS materials having 'delta index' larger than or equal to zero are accepted. Table 3 shows the comparison of material criteria between Japan and France.

Recommendations and timelines:

The limitations on Ni equivalence should be reviewed to include market SUS materials by considering adequacy of those materials carefully. Mitigation of the limitations within 5 years is expected due to the NEDO project "Development of technology for practically disseminating ultra-high pressure hydrogen infrastructure", project No. 18011, ongoing from 2018FY.

Table 3 Standards for austenite SUS as HRS material

| | Ni equivalence | | Delta index (Δ) | |
|---|---|---|---|---|
| Formula | Ni eq.= Ni + 12.6 C + 0.35 Si + 1.05 Mn + 0.65 Cr + 0.98 Mo | | Δ= Ni + 0.5 Mn + 35 C – 0. 0833 [Cr + 1.5 Mo – 20]² – 12 | |
| Definition | Exemplified standards of GHPGSR [2] | | EIGA IGC Doc 121/14 [3] | |
| Criteria | Value of Ni eq. | Temperature / degC | Value of Δ | Temperature / degC |
| | ≥28.5 | -40 ~ -10 | ≥0 | -150 ~ 100 |
| | ≥27.4 | -10 ~ 20 | | |
| | ≥26.3 | 20 ~ 250 | | |
| Remarks | | | • Applicable condition:<br>Hydrogen pressure > 2 bars<br>Oxygen in hydrogen ≤ 300 ppm V<br>Temperature: as above<br>• Maximum contents:<br>S: 0.025 % / P: 0.015 % | |

### 3.3 Certification of anti-explosion proof equipment

In Japan HRS facilities involving equipment with an anti-explosion (anti-Ex) proof certification must be certified independently, which implies additional expenses and time.

Table 4 shows the state of regulations for certification of an anti-Ex proof equipment in Japan, the EU, and the US. All standards referred to in these certifications are technically equivalent to IEC standards (IEC 60079 series) except 'National Difference' adopting local conditions and version of reflected IEC standards. ATEX [4] mandatory for products distributed in the EU does not always require certification by a 'Notified Body'. The US has two types of certifications, NEC 500 and NEC505 as parts of the NFPA70 "National Electrical Code" [5]. NEC 500 is the oldest and the original certification, which is non-compatible with IEC standards. NEC 505 is a newly established certification along IEC standards.

International unified certification, IECEx, has been established among 33 country members to realize economical and fast import of anti-Ex proof equipment between the member countries [6]. However, in actual cases, transforming certification between IECEx and other certifications is not always possible without additional procedures. Transforming certification by ATEX into IEC is actually impossible without additional tests. NEC 505 for US domestic certification was originally made for importing anti-Ex proof equipment certified in the IEC into the US at minimal costs. The opposite transformation, from NEC 505 into IEC, is impossible due to a significant difference in the required tests.

The transformation from IECEx to TIIS (Ro-ken) [7] in Japan, for importing IECEx certified equipment may require additional tests. That transformation is legally possible, but it is actually very difficult due to very severe requirements of TIIS for the test data. The total procedure from IECEx certification to TIIS needs in general from several months to several years. In practical, all the procedures for transferring certification of equipment from IECEx into Ro-ken have to be done by only one company in order to avoid insufficient test data for Ro-ken application. Complete transfer of test data between two other companies is actually impossible and results in performing additional tests.

Recommendations and timelines:

The IECEx certification should be directly transformed into Japanese certification without additional testing or with tiny modifications. The earlier mitigation is desirable, but estimating actual timeline is difficult.

Table 4 Regulations for certification of anti-explosion proof equipment in Japan, EU, and US

| Countries | | Japan | EU | US |
|---|---|---|---|---|
| Basis | | JIS C 60079 | ATEX[*1] | NFPA 70<br>(NEC[*2] 500/505) |
| Compatibility | | IEC | IEC[*3] | UL & IEC[*4] |
| Certification | | Necessary<br>(body: TIIS) | Not always necessary (body: INERIS/LCIE in France, etc.) | Necessary<br>(body: UL/CSA etc,) |
| Transformation | From IECEx | OK with TIIS certification (Ro-ken) | OK | OK |
| | To IECEx | OK | NG | NG |
| | Remarks | JIS completely complies with IEC. | ATEX may not need external certification, which is mandatory to IEC. IEC certification covers all requirements for ATEX. | NEC 505 (new standard) complies with IEC / NEC 500 (conventional) does not complies with IEC |

*1 The EU directive to comply with “Essential Health and Safety Requirements” defined in “Treaty on the functioning of the European Union (TFEU)”, not standard itself.

*2 National Electrical Code. 2 Articles (NEC Article 500 / 505) constitute standards of anti-explosion proof independently.

*3 ATEX harmonizes with EN standards which are compatible with IECs

*4 NEC Article 505 harmonizes with ANSI/ISA & UL standards which are nearly compatible (but including deviations 1,2) with IECs.

## 4 CONCLUSIONS

・Systems and status

Regulation reforms of HRS have been identified by the Japanese government from 2013 as a possible way to rebuild the Japanese economy. In December 2018, 40 items have been considered to mitigate legislative restrictions on OPEX or CAPEX of HRS.

METI, organizations, e.g. KHK and JPEC, and industries cooperatively discuss the reforming items through public hearings.

A special topic for Japanese regulation is an "Exemplified standards" of ministerial ordinance, which defines quantitative limitations (e.g. safety distances and materials) and operated prefectural offices actually restricts how to build an HRS. Almost no freedom of manufacturer to choose specifications of HRS on the performance itself is allowed by the prefectural office. The "Exemplified standard" and ministerial ordinances are the actual targets of the regulation reform of HRS in Japan.

・Specific items

a) Safety distance:

In Japan and France, equipment containing hydrogen has to be kept safely at a specific distance to the HRS frontier. Installing a wall can replace keeping these large safety distances. The Japanese regulation requires the installation of walls between hydrogen-containing equipments in order to avoid a 'domino effect'. Such walls are not required by the French regulation.

b) Mitigation of Ni eq of SUS materials:

Japanese criteria for materials used for HRS equipment consist of 'Nickel equivalence', representing the equivalent of Ni content in the material, similar to the way France uses 'delta index'. In Japan, different Ni eq.s are defined for three temperature ranges corresponding to the severity of the hydrogen embrittlement. In France, only one delta index is defined regardless of the temperature. Some SUS materials used for HRS in France cannot be used in Japan due to differences in criteria.

c) Import of foreign anti-explosion proof equipment :

Using the IECEx certification, an anti-explosion proof equipment with local certifications for the EU nations and the US can be imported with minimum additional tests and processes. Japan always requires TIIS certification (Ro-ken) for the imported equipment with several additional tests even if IECEx is certified. In many cases the TIIS certification is rejected due to insufficient test information.

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