Topics

JIS/ASME activities (related to structural materials)

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In addition to the Japanese Industrial Standards (JIS) and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, there are also standards related to thermal power generation facilities under the jurisdiction of the Ministry of Economy, Trade and Industry (METI) and private standards established by academic associations. Regarding the JIS standard, in addition to activities related to the drafting of the JIS standard, we are contributing through the deliberation of the JIS standard proposal at the Japanese Industrial Standards Committee (JISC). NIMS's research results have been reflected in the establishment of JIS Z 2384:2019 “Atmospheric Corrosion Monitoring Sensor”, revision of allowable stress and life evaluation formula for high chromium steel concerning technical standards for thermal power plant, etc. We have participated in the standard activities as members of the ASME Standards Committee for many years, and contributed by reflecting the research results of NIMS in the standard.

1. Introduction

In addition to the Japanese Industrial Standards (JIS) and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, there are also standards related to thermal power generation facilities under the jurisdiction of the Ministry of Economy, Trade and Industry (METI) and private voluntary standards established by academic associations. This paper outlines the activities of NIMS staff in the development of these various standards.

2. JIS standard

2.1 Japanese Industrial Standards (JIS)

Proposals relating to the establishment, revision, and abolishment of JIS standards are prepared by numerous private organizations such as the Japan Iron and Steel Federation, the Japan Stainless Steel Association, and the Japan Society of Corrosion Engineering, and then the JIS standards are submitted to the competent ministers. After that, the JIS standard proposal is deliberated by the Japanese Industrial Standards Committee (JISC), and the approved JIS standard proposal is reported to the competent minister. Therefore, the activities related to JIS standards are roughly divided into activities related to the drafting by private organizations and the deliberation of JIS standard proposals in JISC.

2.2 Preparation of JIS standards draft

The Japan Iron and Steel Federation, Standardization Center, JIS Drafting Committee for Steel Products, which produces many drafts of JIS standards concerning steel materials such as steel terminology, analysis methods, tensile tests, Charpy impact tests, and various hardness tests in addition to various steel standards, Dr. Ogata, special researcher, has been engaged in the drafting of JIS standards as a vice-chairman of the committee. The Japan Stainless Steel Association has prepared drafts of JIS standards for stainless steel materials and tests, inspections, and certifications, etc., and Kimura has served as the chairman of the drafting committee for many JIS standard preparations.

The atmospheric corrosion monitoring sensor (ACM sensor) using the galvanic couples is a sensor that was researched and developed for monitoring the corrosion rate of metallic materials in the 1990s. In recent years, it has been used for bridges, houses, chemical plants, electric power, automobiles, etc. it is widely used in a wide range of fields

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for purposes such as corrosion life prediction and corrosion environment evaluation. Therefore, to ensure the quality and reliability of ACM sensors, JIS Z2384: 2019 " Atmospheric Corrosion Monitoring Sensor" was standardized in September 2019. The Japan Society of Corrosion Engineering created this draft, and a former Special Researcher Shinohara Tadashi, who researched and developed the ACM sensor, compiled this draft JIS standard as the secretary of the drafting committee and the subcommittee chief.

2.3 Deliberation of JIS standard proposal

The Japanese Industrial Standards Committee has "Basic Policy Board", "Standards Board for ISO area", and "Standards Board for IEC area" under the "Council" that plans the basic matters of business operation. Under each board, there are technical committees that discuss JIS standards. Many of the JIS standard proposals regarding metallic materials are deliberated and approved by the "Technical Committee on Metal and Inorganic Materials", and then approved and reported to the competent ministers . Kimura has served as Chairman of the Technical Committee on Metal and Inorganic Materials, and also as a member of the Standard Boards for the ISO area. Dr. Hiromoto, Principal Researcher serves on the Technical Committee on Metal and Inorganic Materials.

3. Standards for thermal power plant

Technical standards for thermal power plants are shown as concretely showing the technical contents to meet the technical requirements stipulated by the Ministerial Ordinance No.51 of Ministry of International Trade and Industry, 1997 that establishes the technical standards for thermal power plant. This interpretation stipulates the allowable stresses for materials that can be used in thermal power plants.

At the ultra-supercritical thermal power plant that was in operation in June 2004, the high-temperature reheat pipe was damaged, and as a result of investigating the cause and studying countermeasures, the strength of the high chromium steel (KA-SUS410J3) welded material used for the damaged part, that was revealed that the strength was lower than that at the time of design, and the creep strength was similarly reduced in the base metal. Therefore, the comprehensive long-term creep strength of high chromium steel was evaluated and examined based on the latest survey results, and based on the results, the materials specified in "The Interpretation for the technical standards for thermal power plant" we reviewed the allowable tensile stress [1]. To revise the allowable tensile stress, the creep strength was re-evaluated by the "region splitting analysis method" proposed by Kimura. Furthermore, for existing thermal power plants that use the same material, maintenance and management based on appropriate residual life diagnosis will continue to be necessary. Therefore, to diagnose the remaining life of high chromium steel, a life evaluation formula for high chromium steel in thermal power plants for power generation was issued as a document [2]. This life evaluation formula is set based on the 99% lower confidence limit of the creep rupture life evaluated using the "region splitting analysis method". The allowable tensile stress and life evaluation formula for high-chromium steel has been reviewed several times since then, but in each of these reviews, the creep strength evaluation by the "region splitting analysis method" proposed by Kimura was used, it has contributed to the revision of the allowable tensile stress and life evaluation formula of the modified 9Cr-1Mo steel (KA-STBA28 series steel) carried out in July 2019 [3].

4. Domestic private standards

4.1 The Japan Society of Mechanical Engineers power generation facilities codes

In 1995, when the World Trade Organization (WTO) was established, Japan ratified the WTO Agreement and simultaneously signed the TBT (Technical Barriers to Trade) Agreement. The TBT Agreement stipulates ensuring the transparency of creation of a principle and standards for formulating domestic standards based on international standards so that the conformity assessment procedures (standards/standards certification system) for industrial products and other countries with standards and standards do not become unnecessary trade obstacles. Concerning this, in 1997, the technical standard was "Performance Regulation", and the new technology and private standards were utilized by confirming the conformity to the technical standard at the installer's own risk.

Therefore, the Japan Society of Mechanical Engineers established a Main Committee on Power Generation Facility Codes in October 1997 and started standardization activities

for power generation facilities. At the time of its establishment, two subcommittees on thermal power and nuclear power were established under the Main Committee on Power Generation Facility Codes. After that, subcommittees on materials and fusion power were established, and now there are four subcommittees for Thermal, Nuclear, Materials, and Fusion. Subgroups and working groups, which are permanent organizations, are established under each subcommittee. In addition, Tasks are established as temporary organizations corresponding to specific issues.

As of December 2021, Kimura is a member of the Main Committee on Power Generation Facility Codes and a member of the Subcommittee on Materials, Sawada is a member of the Subcommittee on Materials and the leader of the Subgroup on New Materials Standardization under the Subcommittee on Materials and member of the Task Committee on AM Technical Standards under the Nuclear Energy Technical Committee, and Dr. Toda Yoshiaki Principal Researcher of the Integrated Smart Materials Group is an observer of the Subgroup on New Materials Standardization and the Subgroup on Integration of Materials Standards under the Subcommittee on Materials, participating in the standards development activities. Furthermore, Dr. Tabuchi Masaaki Managing Researcher is a member of the Subcommittee on Thermal Power, Dr. Nishikawa Hideaki Senior Researcher of the Fatigue Property Group is a Deputy Chief of the Subgroup on Materials under the Subcommittee on Thermal Power, and Dr. Ono Yoshinori Principal Researcher of the Materials Strength Standard and Technology Group is as a member of the Subgroup on Material under the Subcommittee on Nuclear Power, are participating in the standard development activities.

Regarding the interpretation of the technical standards for thermal power plants, Article 167 was newly established in Chapter 11 “Application of other standards” when revised on February 25, 2016.

"Article 167, Equipment that belongs to thermal power equipment for power generation, and the Mandatory Rules for Thermal Power Generation Facilities (2012 edition) of the Japan Society of Mechanical Engineers JSME S TA0-2012 (including 2015 addenda JSME S TA0-2015) those that comply with the regulations shall meet the technical requirements specified by the Ministerial Ordinance. In this case, the provisions of Chapter 2 to the preceding Chapter on the equipment concerned shall not apply.”

This means that the JSME standard for thermal power plants, which is a private standard, has been officially recognized as a national review standard by the government, and NIMS researchers have contributed greatly to this recognition.

4.2 Welding Engineering Standards (WES)

In recent years, many studies on high cycle fatigue of 10^7 cycles or more have been reported. The Japan Welding Engineering Society conducted researches on ultra-high cycle fatigue of structural materials for nuclear equipment from 2000 to 2011. Among them, ultrasonic fatigue tests were also adopted, and round robin tests were conducted by multiple organizations. As a result of this research, various know-hows on ultrasonic fatigue testing were accumulated, and to promote the widespread use of ultrasonic fatigue testing and expanding ultrahigh-cycle fatigue data, "Standard test method for ultrasonic fatigue testing of metallic materials" was established as Welding Engineering Standard WES 1112: 2017. Dr. Furuya Yoshiyuki, group leader of Fatigue Properties Group, is in charge of writing the draft and commentary of this standard, and standardization was made based on the ultrasonic fatigue test method that Dr. Furuya has been researching and developing for many years.

4.3 High Pressure Institute of Japan Standard (HPIS)

The High Pressure Institute of Japan has established a Committee on Pressure Vessel Codes and Standards to promote design, manufacturing, construction, testing, inspection, maintenance management technology, safety evaluation technology, etc. related to rational high pressure or related to pressure equipment. To do so, the committee is establishing and revising the technical standards based on the latest technical knowledge. Dr. Abe Fujio, Research Adviser, was a member of the the committee, and Kimura succeeded Abe as a member in 2021.

As a committee member, Kimura participated in the Sub-committee on High Pressure Vessel Codes and Standards for drafting the allowable tensile stress tables for pressure vessels and boiler materials, and prepared HPIS C104, "Allowable Tensile Stress Values for Boilers and Pressure Vessels (Design Margin 4)" and HPIS C105, "Allowable

Tensile Stress Values for Boiler and Pressure Vessels (Design Margin 3.5)". HPIS C104 and HPIS C105 are the standards cited in the allowable tensile stress tables in JIS B 8265 "Construction of pressure vessel - General principles" and JIS B8267 "Construction of pressure vessel", respectively. Kimura also participated as a member of the drafting committee for HPIS C108 "Code for Nuclear Fuels Reprocessing Facilities Materials Standard".

5. ASME Boiler and Pressure Vessel Code

In the early 1900s, there were many boiler and pressure vessel explosion accidents in the United States, which resulted in many deaths and injuries. Therefore, the American Society of Mechanical Engineers (ASME) started the development of boiler and pressure vessel standards to design boilers and pressure vessels safely. Previously, the revised version of the standard was issued every three years, and the supplement (Addenda) was issued in the year when the revised version was not issued, but after the 2015 version, the revised version of the standard is issued every two years. And the supplement is no longer issued. Table 1 shows the layout of the latest version of the 2019 standard. The ASME Boiler and Pressure Vessels Code is composed of 12 sections in total, Section 1 is for Power Boilers, Section 2 is for Materials, and Section 3 is for Construction of Nuclear Facility Components. There is a standard committee corresponding to each section, and there are many subgroups, working groups, task groups, etc. under the standard committee. The ASME Boiler and Pressure Vessel Code Committee discuss the proposed standards by concentrating over 200 conferences during the Boiler Code Week four times a year.

For many years, Research Adviser Dr. Abe Fujio from the National Institute for Materials Science has been working as a member of on many committees on Materials for Section II as an active member on Subgroup on Strength, Ferrous Alloy, Working Group on Creep Strength Enhanced Ferritic Steels, Working Group on Data Analysis, Working Group on Materials Database, etc. Kimura has been a member of the Committee on Materials in Section II since 2019 and participated in the standard development activities as a member of Subgroup on High Temperature Reactor and Working Group on Allowable Stress Criteria on the construction of nuclear facility components in Section III. As a result of the activities so far, we proposed a material strength standard value for 9Cr-1Mo-V steel (Grade 91, Modified 9Cr-1Mo steel) up to a maximum of 500,000 hours, and the proposed revision of the material strength standard values up to 300,000 hours established by the existing standard was proposed, and a new material strength standard value for 500,000 hours was approved and reflected in the 2019 Edition of the standard. In Japan, the United States, and Europe, while a material strength standard value of up to 500,000 hours was being considered as a design standard for the fourth generation (Generation IV) reactor, we contributed to the world's first establishment of the material strength standard for 500,000 hours of 9Cr-1Mo-V steel. Currently, Kimura is in charge as a Project Technical Manager to study the establishment of a stress rupture factor for 9Cr-1Mo-V steel for up to 500,000 hours and is proceeding with deliberation.

6. Summary

This paper has outlined the efforts of NIMS researchers for JIS/ASME standards, as well as for METI's thermal power plant standards and other private standards. There may be other contributions by NIMS researchers to standardization activities than those described here. Standardization is an important task for NIMS researchers as well, as it is directly related to our daily life, and NIMS researchers need to be organized to further enhance these activities.

References

1) The Interpretation for the technical standards for thermal power plant, Nuclear and Industrial Safety Agency, Ministry of Economy, Trade and Industry, December 14, 2005, NISA-234c-05-8. (in Japanese)
2) A Life evaluation formula for high chromium steel in thermal power plants, Nuclear and Industrial Safety Agency, Ministry of Economy, Trade and Industry, December 14, 2005, NISA-234c-05-9. (in Japanese)
3) Regulations to revise a part of the interpretation for the technical standards for thermal power plant, Ministry of Economy, Trade and Industry, July 4, 2019, 20190628 Hokyoku No. 1 (in Japanese)

Table 1: List of sections of ASME Boiler and Pressure Vessel Code (2021Edition)

I	Rules for Construction of Power Boilers
II	Materials
	• Part A — Ferrous Material Specifications
	• Part B — Nonferrous Material Specifications
	• Part C — Specifications for Welding Rods, Electrodes, and Filler Metals
	• Part D — Properties (Customary)
	• Part D — Properties (Metric)
III	Rules for Construction of Nuclear Facility Components
	• Subsection NCA — General Requirements for Division 1 and Division 2
	• Appendices
	• Division 1
	– Subsection NB — Class 1 Components
	– Subsection NCD — Class 2 and Class 3 Components*
	– Subsection NE — Class MC Components
	– Subsection NF — Supports
	– Subsection NG — Core Support Structures
	• Division 2 — Code for Concrete Containments
	• Division 3 — Containment Systems for Transportation and Storage of Spent Nuclear Fuel and High-Level Radioactive Material
	• Division 5 — High Temperature Reactors
IV	Rules for Construction of Heating Boilers
V	Nondestructive Examination
VI	Recommended Rules for the Care and Operation of Heating Boilers
VII	Recommended Guidelines for the Care of Power Boilers
VIII	Rules for Construction of Pressure Vessels
	• Division 1
	• Division 2 — Alternative Rules
	• Division 3 — Alternative Rules for Construction of High Pressure Vessels
IX	Welding, Brazing, and Fusing Qualifications
X	Fiber-Reinforced Plastic Pressure Vessels
XI	Rules for Inservice Inspection of Nuclear Power Plant Components
	• Division 1 — Rules for Inspection and Testing of Components of Light-Water-Cooled
	• Division 2 — Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Power Plants
XII	Rules for Construction and Continued Service of Transport Tanks
XIII	Rules for Overpressure Protection