Trends in International Standardization of Superconductivity

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De jure standards published by internationally acknowledged organizations such as the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) are known as "consensus-based" standards. Currently, such international standards are becoming more important in conducting global business, and are especially effective for expanding market in the early phases of product development and for reducing costs in business enhancement activities. In the field of superconductivity technology, IEC has been engaged in international standardization activities since 1988, when the development of high-temperature superconductors had started. The IEC Technical Committee 90 (TC90) was established in the following year, and has published, as of today, 19 international standards. In the report the author traces 20 years of history of IEC TC90 by summarizing its accomplishments and lessons learned with hope that this report will contribute to future development of superconductivity technology.

Keywords: Superconductor, International Standard, IEC

1. Introduction

Both De jure standards published by internationally acknowledged organizations, such as the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO), and forum standards published by industrial groups are known as "consensus-based" standards [(1)]. These standards are acknowledged as one of the intellectual properties. As compared with De fact standards, which were highlighted in the past, these consensus-based standards were not always regarded as effective methods. This was because such standards required two or more companies to make a decision, each process to reach consensus took long time, and there were severe restrictions on the involvement of patented technologies in such standards. The IEC, headquartered in Geneva, Switzerland, was founded in 1906 and has 69 member countries as of today. In 1989, IEC established its 90th Technical Committee (TC90): Superconductivity. Since then, the TC90 has published 19 international standards in the superconductivity field. In this report the author traces 20 years of history of IEC TC90 by summarizing its accomplishments and lessons learned with the hope that this report will contribute to the future development of superconductivity technology.

2. Principal Role of International Standards

"The Agreement on Technical Barriers to Trade" adopted by World Trade Organization (WTO) stipulates that countries adopt international standards as their foundation standards. Therefore, our products should be based on international standards in today's global market. Among various intellectual property rights, a greater importance has been placed on patents and Japan is one of the world leaders in the number of patent application. Despite the fact, Japan falls far behind Europe and the U.S. in embracing international standards. The reasons for this are likely that the merits of international-standardization activities are undervalued and those who involve in such activities are not adequately appreciated.

The recent studies in this field revealed that mainly two substantial merits existed in the adoption of international standards. One is its effectiveness for expanding market in the early phases of product development and the other is cost efficiency in business enhancement activities. Thus, the international standards are becoming increasingly important to promote global businesses as well as the protection of our own technologies by patents.

It is strategically important for each company to make a right decision which part of a product should be standardized or should be covered with business models including patents.

3. History of Standards in IEC's Superconductivity Field

IEC initiated its standardization activities in the superconductivity field after the discovery of high-temperature superconductors, more specifically, in 1987 when the critical temperature of high-temperature superconductor exceeded the temperature of liquid nitrogen (77.3 K). At that time, there were only two standards in this field throughout the world: Standard terminology relating to superconductors, ASTM B713-82; and Standard test method for D-C critical current of composite superconductors, ASTM B-714-82.

In 1988, Special Working Group on Superconductivity (SWG-S) was established under the direct control of IEC's Committee of Action (currently, the Standardization Management Board) to discuss what could be done by IEC with standards in this field because high-temperature superconductors would make great impacts on our society. Japan assumed the secretariat position in the SWG-S because Japan has actively promoted R&D and achieved outstanding results in this field. In Japan, it was unanimously agreed to participate in this activity from the following viewpoints:

① It was beneficial for Japan to establish IEC standards first and then translate them into Japanese as its own standards, so that domestic standards would not make international trade barriers amid severe trade friction at that time.

② International standards in the superconductivity field were required because of enormous expectations for high-temperature superconductors, which were discovered in 1986.

③ Unified criterions would enable different research bodies to compare their R&D data and results and promote R&D activities further.

④ To exercise leadership in the high-temperature superconductivity, Japan needed to proactively take part in the international standardization activities.

⑤ Japan aimed to strengthen its presence for IEC.

Table 1. Items for standardization in TC90

1.	Terms and definitions.
2.	Measurements. 2.1 Raw materials (including materials used for superconductors and real apparatus). 2.2 Wire, bulk and film.
3.	Material specification. 3.1 Raw materials. 3.2 Wire, bulk and film.
4.	Equipment and device performance and tests specifications.

In May 1989, a meeting of SWG-S was held at the international meeting room of Ministry of Economy, Trade and Industry (METI) with the attendance of six countries. In June 1989, SWG-S proposed its recommendation for setting up a new technical committee on superconductivity because demand for superconducting apparatus was rapidly and firmly increasing and common evaluation criterions were required for fast-changing high-temperature superconductive technologies. In July 1989, the Committee of Action and Council meeting of IEC discussed the recommendation and concluded to set up TC90. Japan was appointed as its Secretariat. This was the first time for Japan to assume the Secretariat of TC, and taking such leadership in the international standardization of a high-technology field had a significant meaning for Japan.

Representatives from Japanese organizations, laboratories and professionals in related industries gathered to conduct the Secretariat role, and nominated Dr. Robert Kamper, National Institute of Standards and Technology (NIST), as Chairman of TC90 (at present, Dr. Loren Goodrich, NIST).

In May 1990, the first general meeting of TC90 was held in Tokyo with the attendance of eight countries: Australia, Belgium, Czechoslovakia, France, Japan, Poland, U.K. and U.S. At this meeting, the members decided the scope and schedules of TC90's standardization activities. **Table 1** shows the items for standardization in TC90.

4. Present Status and Future Prospects of IEC Standardization on Superconductivity

4-1 Current State of the Organization

TC90 started its full-scale activities towards international standardization after the first general meeting in Tokyo in 1990. **Table 2** shows its history until now. **Table 3** shows its scope and participants. Versailles Project on Advanced Materials and Standards (VAMAS) is a liaison organization which was doing pre-standardization work. TC90 has taken VAMAS's results into its international standards. P-member (P stands for Participating) refers to a country which is obliged to vote and participate in meetings and preparations for standardization. O-member (O stands for Observatory) refers to a country which has a right to participate in meetings, to receive relative documents and to make comments on them.

TC90 started its activities with gathering and defining terms related to the superconductivity field and establishing standards for test methods to measure various performance [(2)-(3)]. As Lord Kelvin, the first President of IEC, said "If you cannot measure it, you cannot improve it," test methods are vital for performance improvement.

Table 4 shows Working Groups (WGs) which work for individual preparations of documents. In 2007, TC90 set up its first component/device-level WG as WG12: Current leads.

Table 5 shows international standards published by TC90. According to the scope, TC90 has established a wide range of standards from low-temperature supercon-

Table 2. History of TC90

1988	Special WG–Superconductivity under the Committee of Action was established to discuss what IEC could do in the field of superconductivity (Secretariat: Japan)
1989	A new TC was proposed at Council meeting in Brighton, U.K. Setting up TC90: Superconductivity (Chairman: U.S., Secretariat: Japan)·Japan's first Secretariat in TC level
1990	The first general meeting in Tokyo
1991-2005	From the second through ninth general meetings
2006	The 10th general meeting in Kyoto
June 2008	The 11th general meeting in Berlin
October 2008	Confirmed the collaboration with TC20 in superconducting cable field

Table 3. Scope and membership of TC90

Scope	–To deal with technical aspects, problems and standard activities related to superconducting materials and devices. –All the classes of superconductors will be covered
Liaison A)	VAMAS (Versailles Project on Advanced Materials and Standards)
P-member	Austria, China, France, Germany, Italy, Japan, Republic of Korea, Poland, Romania, Russian Federation, U.S. (11 Countries)
O-member	16 Countries

Table 4. Working groups of TC90

WG 1	Terms and definitions
WG 2	Critical current measurement of Nb-Ti composite superconductors
WG 3	Critical current measurement method of oxide superconductors
WG 4	Test method for residual resistivity ratio of Cu/Nb-Ti and Nb_3Sn composite superconductors
WG 5	Tensile test of composite superconductors
WG 6	Matrix composition ratio of Cu/Nb-Ti composite superconductors
WG 7	Critical current measurement method of Nb_3Sn composite superconductors
WG 8	Electronic characteristic measurements
WG 9	Measurement method for AC losses in superconducting wires
WG 10	Measurement for bulk high temperature superconductors - Trapped flux density in large grain oxide superconductors
WG 11	Critical temperature measurement - Critical temperature of composite superconductors
WG 12	Current leads

ductors to high-temperature superconductors. **Figure 1** shows the numbers of standards published by TC90 on a yearly basis.

4-2 Learned Lessons and Future Prospects

It took about 10 years for TC90 to publish the first international standard since its foundation. This delay was caused mainly because:

① it took a long time to build networks with experts
② it lacked sophisticated negotiation skills among foreign countries
③ it required to get used to the documents forms of international standards

Considering such efforts, long-term strategies and readiness are essential for consensus-based standard activities.

As the future activities, TC90 will promote the standardization of test methods and prepare for the standardization of high-temperature superconducting apparatus, which will be put into practical use in near future. TC90 held international panels on international standards activity at various international academic conferences for researchers to deepen their understanding in order to achieve international consensus, as shown in **Table 6**. In November 2008, we had a panel in Tsukuba City, Ibaraki Prefecture, Japan, and about 50 persons attended it to discuss TC90's future directions.

Furthermore, for standardization on superconducting power cables, TC90 has started working with TC20: Electric Cables and jointly decided to request Interna-

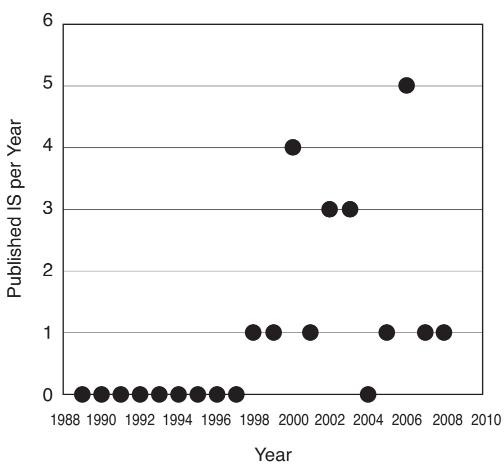

Fig. 1. IEC standards published by TC90

Table 5. IEC international standards published by TC90

IEC 60050-815	International Electrotechnical Vocabulary-Part 815 : Superconductivity
IEC 61788-1 Ed. 2.0	Superconductivity - Part 1 : Critical current measurement - DC critical current of Cu/Nb-Ti composite superconductors
IEC 61788-2 Ed. 2.0	Superconductivity - Part 2 : Critical current measurement - DC critical current of Nb_3Sn composite superconductors
IEC 61788-3 Ed. 2.0	Superconductivity - Part 3 : Critical current measurement - DC critical current of Ag-sheathed Bi-2212 and Bi-2223 oxide superconductors
IEC 61788-4 Ed. 2.0	Superconductivity - Part 4 : Residual resistance ratio measurement - Residual resistance ratio of Nb-Ti composite superconductors
IEC 61788-5 Ed. 1.0	Superconductivity - Part 5 : Matrix to superconductor volume ratio measurement - Copper to superconductor volume ratio of Cu/Nb-Ti composite superconductors
IEC 61788-6 Ed. 2.0	Superconductivity - Part 6 : Mechanical properties measurement - Room temperature tensile test of Cu/Nb-Ti composite superconductors
IEC 61788-7 Ed. 2.0	Superconductivity - Part 7 : Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies
IEC 61788-8 Ed. 1.0	Superconductivity - Part 8 : AC loss measurements - Total AC loss measurement of Cu/Nb-Ti composite superconducting wires exposed to a transverse alternating magnetic field by a pickup coil method
IEC 61788-9 Ed. 1.0	Superconductivity - Part 9 : Measurements for bulk high temperature superconductors - Trapped flux density of large grain oxide superconductors
IEC 61788-10 Ed. 2.0	Superconductivity - Part 10 : Critical tempera ture measurement - Critical temperature of Nb-Ti, Nb_3Sn, and Bi-system oxide composite superconductors by a resistance method
IEC 61788-11 Ed. 1.0	Superconductivity - Part 11 : Residual resistance ratio measurement - Residual resistance ratio of Nb_3Sn composite superconductors
IEC 61788-12 Ed. 1.0	Superconductivity - Part 12 : Matrix to superconductor volume ratio measurement - Copper to non-copper volume ratio of Nb_3Sn composite superconducting wires
IEC 61788-13 Ed. 1.0	Superconductivity - Part 13 : AC loss measure ments - Magnetometer methods for hysteresis loss in Cu/Nb-Ti multifilamentary composites

Table 6. International standard panels held by TC90

Year	Venue	International Conference
October, 2004	Jacksonville, USA	Applied Superconductivity Conference
September, 2005	Vienna, Austria	European Conference on Applled Superconductivity
September, 2005	Genoa, Italy	Magnet Technology-19
November, 2005	Tsukuba, Japan	International Superconductivity Symposium
August, 2006	Seattle, USA	Applled Superconductivity Conference
October, 2006	Nagoya, Jpapan	International Superconductivity Symposium
August, 2007	Philadelphia, USA	Magnet Technology-20
November, 2007	Tsukuba, Japan	International Superconductivity Symposium
November, 2008	Tsukuba, Japan	International Superconductivity Symposium

tional Council on Large Electric Systems (CIGRE) to start pre-standard activities at the TC90 general meeting in Berlin in June 2008.

CIGRE decided in August 2008 to establish Task Force named B1.TF31: Testing of Superconducting Cable Systems, whose mission was investigating topics and formulating scopes and terms of reference for upcoming Working Groups.

A 20-year history of TC90 activities was reviewed above and lessons from the activities can be summarized as follows:

① Long-term strategies and readiness are indispensable to establish the know-how of designing IEC standards among each working group and experts, as it required about 10 years to be familiar with such standard forms.

② Liaison relationships are necessary as TC90 published international standards based upon the activities of VAMAS which has done pre-standard researches.

③ Having opportunities to discuss and make consensus among related researches is essential for future directions.

④ Governmental participation is necessary for premature industries such as superconductivity because in such case, the benefit principle doesn't work.

5. Summary

Future schedule for international standardization on high-temperature superconducting apparatus is shown in **Fig. 2** [4]. It is understandable that TC90 needs long-term strategies if international consensus and following practical term needed for IEC standard preparation are took into consideration.

In the future, TC90 will head for the international standardization of high-temperature superconducting apparatus, which will be a 28 billion dollar market world wide at 2020. The author sincerely hopes that Japan can contribute to the international standardization and actual implementation of superconductive technologies.

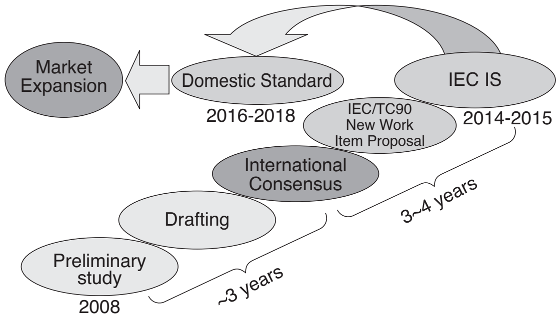

Fig. 2. Future schedule of TC90

6. Acknowledgements

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