Present Status of International Standardization Activities for Superconductivity

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2011 celebrates the centennial anniversary of the discovery of superconductivity by Prof. Heike Kamerlingh Onnes in 1911. High-temperature superconductivity (HTS) was also discovered 25 years ago, and its actual implementation has just started. The International Electrotechnical Commission (IEC) has promoted the standardization of superconductivity since the foundation of Technical Committee 90 (TC90) in 1989. This paper describes the present status of international efforts to standardize superconductivity and gives a future perspective on standardization.

Keywords: standards, superconductor, superconductivity, cable, wire

1. Introduction

When looking at the history of superconductivity and the International Electrotechnical Commission (IEC), very interesting aspects are noticed. The important events are listed chronologically as follows:

1906: The IEC is founded. The 1st President is Lord Kelvin.
1908: Prof. Heike Kamerlingh Onnes succeeds in liquefying helium.
1910: Japan joins the IEC.
1911: Prof. Heike Kamerlingh Onnes discovers superconductivity.
1986: Drs. J.G. Bednorz and K.A. Müller discover high-temperature superconductivity (HTS).
1989: Technical Committee 90 (TC90); Superconductivity is founded at the IEC general meeting in Brighton, the UK.

As we see, important events happened closely together.

2. International Organizations Related with Standardization Activities for Superconductivity

International organizations related to standardization activities are grouped into two categories. One is the organization for developing international standards, the IEC [(1)], and the others are two organizations studying related technical issues. For material issues, the Versailles Project on Advanced Materials and Standards[(2)] (VAMAS), and for electrical system issues, the International Council on Large Electric Systems[(3)] (CIGRE).

2-1 Outline of the IEC

The IEC is a non-governmental organization with headquarters located in Geneva, Switzerland. Official members total 60 countries, and the Japan Industrial Standards Committee (JISC) is the Japanese member.

The annual budget is about 19.6 million SFr, 52% of which is covered by official member countries. In 2011, the Japanese fee was 884,000 SFr (8.5% of the total). France, Germany, the UK and the U.S. contribute the same fee amount as Japan.

In the IEC, the Standardization Management Board (SMB) manages the overall activity of standards development, while Technical Committee (TC) develops each of the standards. In total there are 94 TCs with 80 subcommittees (SCs) created under the TCs. The Secretariat country of each TC and SC is responsible for standards development. The chairman of each TC is nominated by the Secretariat and appointed by the SMB. The chairman is responsible for management of the respective TC, and may be appointed from the countries other than the Secretariat.

Within each TC and SC, Working Groups (WGs) are created to develop relevant standards, for example "Room temperature tensile test of Bi-2223 superconducting wires." To start a new relevant program, a New Work Item Proposal (NWIP) is first proposed, and the approval of a simple majority of Participating Members (P-members) and nomination for experts are required. P-members in each TC are member countries that actively develop standards.

Table 1. TC90 Working Group

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

Table 2. Structure of the TC90 WG

WG	Convenors		Experts
1	T. Matsushita (JP)	L. Cooley (US)	8
2	K. Osamura (JP)	–	9
3	G. Nishijima (JP)	–	15
4	D. H. Kim (KR)	T. Matsushita (JP)	5
5	K. Osamura (JP)	H. S. Shin (KR)	13
6	T. Shintomi (JP)	–	4
7	J. Parrell (US)	G. Nishijima (JP)	10
8	S. Kosaka (JP)	S. Y. Lee (KR)	17
9	E. W. Collings (US)	K. Funaki (JP)	10
10	M. Murakami (JP)	–	8
11	K. Nakao (JP)	K. W. Lee (KR)	10
12	T. Mito (JP)	–	8
13	K. Osamura (JP)	–	7

Each TC has a determined number of nominated experts, and at least four countries nominate experts in the case of TC90. As shown in **Table 1**, 13 WGs exist within TC90. **Table 2** shows the Convenors and number of experts for each WG. Altogether, there are about 150 experts.

The total annual number of International Standards (ISs) published by the IEC ranges from 366 to 483/year (2006 - 2010), and the total annual number of proposed NWIPs ranges from 163 to176/year (2006 - 2010).

The number of Secretariats accepted by each country and the number of NWIPs proposed by each country are listed in **Table 3**. The number of NWIPs proposed by Japan is at a top level. The numbers of NWIPs proposed by Korea and China tell you that these two countries are also active in IEC activities.

Table 3. Number of Secretariats and NWIP (2008-2010)

Country	Secretariats			NWIPs			
	TC	SC	Total	’08	’09	’10	Total
Germany	18	16	34	27	19	22	68
France	8	16	24	13	1	14	28
U.S.A.	13	11	24	32	10	29	71
U.K.	11	8	19	9	4	6	19
Japan	7	8	15	28	23	21	72
Italy	7	6	13	6	3	12	21
Sweden	3	3	6	5	2	0	7
China	4	1	5	21	18	12	51
Spain	2	2	4	0	0	0	0
Switzerland	2	2	4	2	4	6	12
Canada	3	0	3	2	5	1	8
Korea	2	1	3	12	22	21	55

2-2 Outline of VAMAS

At the Versailles Summit in 1982, it was agreed to create a working group to promote science and engineering and their international collaboration, and strive toward revitalizing the economy. VAMAS has been active since 1986 in international activities for pre-standardization of advanced materials and standards.

First, Technical Working Area (TWA) 6 was created to handle superconducting materials and cryogenic engineering materials, and in 1993 TWA 16 was established for superconducting materials. VAMAS was registered as the TC90 formal liaison organization in 1989 when TC90 was established.

VAMAS member countries are Australia, Brazil, Canada, Taiwan, France, Germany, India, Italy, Japan, Mexico, South Africa, Korea, the UK, the U.S. and the EC.

Among the IEC standards published by TC90, most were studied technically in VAMAS and then completed in TC90 as IEC standards. The IEC recommends establishing liaison relationships with other international organizations to share scientific study results before international standardization activities and to avoid duplication of international work.

The chairman of VAMAS-TWA16 is Dr. H. Kitaguchi, National Institute for Materials Science, Japan. VAMAS-TWA16 is currently managing 4 WGs, involving about 100 researchers from 15 countries(4). **Table 4** shows the structure of VAMAS-TWA16.

Table 4. Structure of VAMAS-TWA16

WG		Item
WG-1: Wire and tape	WG1-1	Bending strain effect
	WG1-2	Tc
	WG1-3	Irreversibility field
	WG1-4	AC loss
WG-2: Bulk	WG2-1	Trapped field
WG-3: Thin film	WG3-1	Surface resistance
WG-4: Mechanical property	WG4-1	BSCCO Mechanical property
	WG4-2	Nb_3Sn Tensile test

2-3 Outline of CIGRE

CIGRE was established by Mr. Jean T. Laspiere in France in 1921 after the IEC was established. CIGRE is a non-profit and non-governmental organization established to discuss technical issues in electricity transmission and distribution, which were progressing remarkably at that time. Its structure is based on discussions among individual participants. Today the number of participating members is 6,400 including individual, group and educational institutions. In CIGRE, relevant discussions are held in Study Committees (SCs).

At present, three SCs are related to superconductivity: A3, High voltage equipment; B2, Insulated cables; and D1, Materials and emerging test techniques. Usually, SCs establish WGs to study agreed items. WGs conduct their study for 3-5 years and then publish a report. If necessary, they proceed to the additional study steps.

Present typical examples are: WG A3.23, Application and feasibility of fault current limiters in power systems; WG B1.31, Testing of superconducting cable systems; and WG D1.38, Emerging test techniques common to high-temperature superconducting (HTS) power applications.

CIGRE itself does not develop any standards, but rather studies and discusses the present technical aspects and technical issues. CIGRE is an organization that does pre-standardization activities like VAMAS.

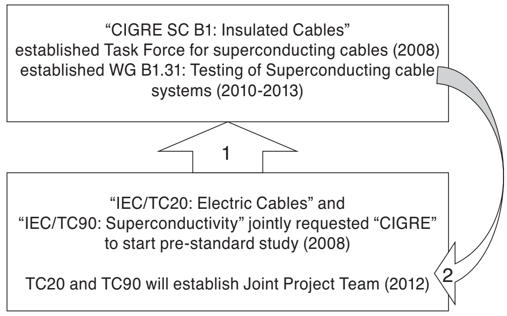

Fig. 1. Standardization of superconducting cables

3. Present Status of International Standardization for Superconductivity

Since the establishment in 1989, TC90 has published 15 IEC standards including terminology, IEC 60050-815. These IEC standards are mainly on measurement methods for metallic superconductors, high-temperature oxide superconductors, and electronic characteristic measurement methods. In 2010, an IEC standard on measurement methods for current leads was published as the first standard for device and equipment levels.

TC90 topics in the last five years are:

(1) As a technical requirement for today, it was agreed to use the term "uncertainty" instead of "accuracy" and "precision."
(2) Superconductivity standardization panel discussions were held in parallel with international conferences to discuss the standardization items and their necessity among world researchers.
(3) Ahead of the general meeting of TC90 which is held biannually, a mini-symposium is also held to have a plenty of time for discussion among the delegates.
(4) Start of collaboration with IEC product committees to keep pace with the progress of superconducting equipment.
(5) Start of collaboration with CIGRE, in addition to VAMAS, as the formal liaison.

As an example of the above-mentioned liaison, the standardization for superconducting cables is introduced. In the IEC, we have TC20, Electric cables, which deals with conventional power cable issues. At this time, the practical

Table 5. Worldwide main projects in superconducting cables (◎: DI-BSCCO)

Area	Project	Voltage kV	Current kA	Length m	Site	Wire		Stage		Notes
						Bi	Y	R&D	Demo	
Japan	TEPCO/SEI	66	1	100	Lab	◎		●		Finished
	Chubu (DC)	20	2	200	Lab	◎		●		In operation
	ISTEC	66/275	5/3	15/30	Lab		●	●		Plan
	Yokohama	66	3	250	Grid	◎			●	Plan to Grid
USA	Albany, NY	34.5	0.8	350	Grid	◎	●		●	Finished
	Ohio	13.2	3	200	Grid	●			●	In operation
	LIPA	138	2.4	600	Grid	●			●	In operation
	Hydra	13.8	4	200	Grid		●		●	Plan
EU	Denmark	30	0.2	30	Grid	●			●	Finished
	Amsterdam	50	3	6000	Grid				●	Plan
	VNIIKP	20	1.4	200	Grid	◎			●	Plan to Grid
China	Yunnan	35	2	33.5	Grid	●			●	In operation
	Lanzhu	10.5	1.5	75	Factory	●			●	Super Substation
	IEE/CAS (DC)	1.3	10	380	Factory	◎			●	Plan to install
Korea	KEPCO	22.9	1.25	100	Lab	◎		●		In operation
	DAPAS1	22.9	1.25	100	Lab	●		●		In operation
	DAPAS2	154	3.75	30	Lab	●		●		Plan
	GENI	22.9	1.25	410	Grid		●		●	Plan to Grid

use of superconducting cables is on the way, with in-grid demonstrations being done in North America, Europe and Asia, smoothing the way to creating standards for superconducting cables in collaboration with TC20 and TC90. **Table 5** shows the main projects related to superconducting cables. TC90 began discussions with TC20 in 2008, and jointly requested CIGRE to start a pre-standards study. As a result, CIGRE established WG B1.38 as mentioned above. A joint project team between TC20 and TC90 will be established in 2012 to start the IEC's activity of standardization for superconducting cables.

4. Future Trends

In the field of superconductivity, magnetic resonance imaging (MRI) device, nuclear magnetic resonance (NMR) device and accelerator equipment are built using superconducting technology as an indispensable technique using metallic superconductors. Hereafter, power cables, transportation devices, motors and various types of magnets for manufacturing processes will incorporate high-temperature superconductors. Moreover, superconducting sensors will be used as sensing devices for precise level detection that is currently not possible using conventional technology.

Thus, superconductivity technology will be used among a wider and far different variety of users than before. **Table 6** shows five typical application fields of superconductivity.

Table 6. Superconductivity applications

Field	Prototypes
Energy equipment	Power cables (AC and DC), Fault current limiters (FCLs), Transformers, Superconducting magnetic energy storage (SMES), Generators
Transportation	Ship propulsion motor, Electric vehicle, Maglev
Information and communication	DC power cable, Microwave filter
Manufacturing	Magnetic billet heater, B-H curve tracer, Silicon single-crystal pulling equipment
Medical and analysis	NMR and MRI devices

In the standards activity of superconductivity, the overall picture was not constructed in a systematic manner but rather issues were approached one by one.

In 2010, the IEC stressed the "system approach," which means that it is necessary to first see the overall picture and later consider relevant individual standards.

Because of the wide range of applications and the IEC's emphasis on taking a system approach, it was necessary to reconstruct an overall system view to make it easier and more understandable for many people who are not familiar with superconducting technology. In view of this trend, WG13 was established in 2011 to promote the study on general characteristics of practical superconducting wires as the first attempt of this kind.

5. Conclusion

There is a general understanding that Japan is not so active in international standardization compared with the U.S. and Europe. In the field of superconductivity, however, Japan leads the international standardization activities, proposing a major portion of the IEC's NWIPs. These accomplishments are the result of support from the Japanese Ministry of Economy, Trade and Industry and related persons. I would like to express sincere thanks to all the people involved and to Sumitomo Electric Industries, Ltd.

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