International Standardization of 1100 kV UHV Transmission Technologies Originating from Japan

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1. Introduction

A world economy expands over boundaries between countries and regions. In Japan, there are many splendid technol-ogies which the world requires. In order to transfer these technologies to the world, an inter-national standard which includes them as a standard is necessary. An international trade is required to comply with an international standard under the Agreement on Technical Barrier to Trade (TBT) of the World Trade Organization (WTO). The International Electrotechnical Commission (IEC) standard is approved as an international standard in an electrical engineering field. In this situation, it becomes important for Japanese splendid technologies to be utilized in the world market that Japanese technologies are developed by basing on the IEC standard and/or Japanese technologies are reflected in the IEC standard.

On the other hand, the International Council on Large Electric Systems (CIGRE) has taken a role of preparing a pre-document for an IEC standard in the electric power system. It will be important to input Japanese technologies in a CIGRE draft as a pre-standard stage. It might be desired that Japanese splendid technologies are presented at the Institute of Electrical Engineers of Japan (IEEJ) conferences including general meetings and committee meetings, then are summarized in IEEJ's technical reports of sub-committees, are presented at CIGRE conferences and finally are adopted in a draft of an IEC standard.

The 1100 kV (Ultra-High-Voltage, UHV) transmission system technology can be said to be a superior technology, which originated from Japan, since it has been initiated first in the world. The activities of reflecting the UHV technology in the IEC standard have been promoted by a cooperation of related organizations gathered in the International Standardization Committee on UHV System in the IEEJ Electrotechnical Committee[1][2].

In the IEC, the Sector Board 1(SB1), which covers the field of 'electricity transmission and distribution' has recommended the necessity of UHV standardization and the Joint IEC-CIGRE coordination group (JICCG) has been established to coordinate the UHV standardization, and coordinate opinions of countries and regions. In the CIGRE, study committees are initiated to investigate the UHV technologies, and are trying to propose drafts rapidly.

These activities toward the international standardization of UHV system are described in this article.

2. UHV Transmission System in Japan

The Tokyo Electric Power Company, Inc. (TEPCO) has worked to expand the 550 kV network. It was, however, very difficult to secure multiple power transmission routes in Japan. In addition, counter- measures for short circuit capacity problems were required in order to increase the number of 550 kV transmission lines. It was finally decided to construct 1100 kV transmission lines with a capacity 3 to 4 times greater than that of 550 kV transmission lines.

The TEPCO completed the 1100 kV transmission route that links a nuclear power station on the Sea of Japan to the metropolitan region (north-south route) in 1993 and the other route linking power sources on the Pacific Ocean (east-west route) in 1999. These transmission lines are now operated at 550kV and they are expected to be upgraded to 1100 kV in 2010's in order to enhance transmission power from east to west in the control area in terms of transient stability and power flow security.

For UHV transmission system design, a self-supporting double-circuit configuration has been adopted as the first attempt in the world.

For substation design, a gas-insulated switchgear (GIS) has been adopted. Various verification tests have been conducted at UHV equipment test site in Shin-Haruna Substation for unexpected phenomena that had not been revealed in the development stage, and for acquisition of various field data. A photograph of the test site has appeared on the cover of EINA, No. 3, 1996.

3. International Standardization through IEC

(1) Organization of IEC

Fig. 1 shows a schematic diagram of the IEC organization related to the UHV standardization. At the top of the organization there is the general meeting, below which Standardization Management Board (SMB) is located. SMB consists of 15 members of the National Committee representative, and important issues are discussed and decided at the SMB meeting.

Technical Committees (TCs) and Sub-committees (SCs) comprise a major body for drafting a standard. They operate with reporting to and being directed by SMB. Three Sector Boards (SBs) operate under SMB now. SB1, SB3 and SB4 have his own field of focusing. The title name of SB1 is 'Electricity Transmission and Distribution', which means that SB1 is responsible for

electric power transmission and distribution network system and equipment.

Members of SBs are nominated by the National Committee and approved by SMB members voting. There are three members including a chair, Prof. H. Ikeda, from Japan. Including two members from both Korea and China, members gather from the world such as USA, Canada, France Germany and South Africa. Related TCs can participate the SB meeting.

The expected function of the SB is: first, to advice on the priority in the sector activities, secondly, to ensure the continuing market relevance of IEC standards, thirdly, to ensure the coherence of standardization activities at the system level.

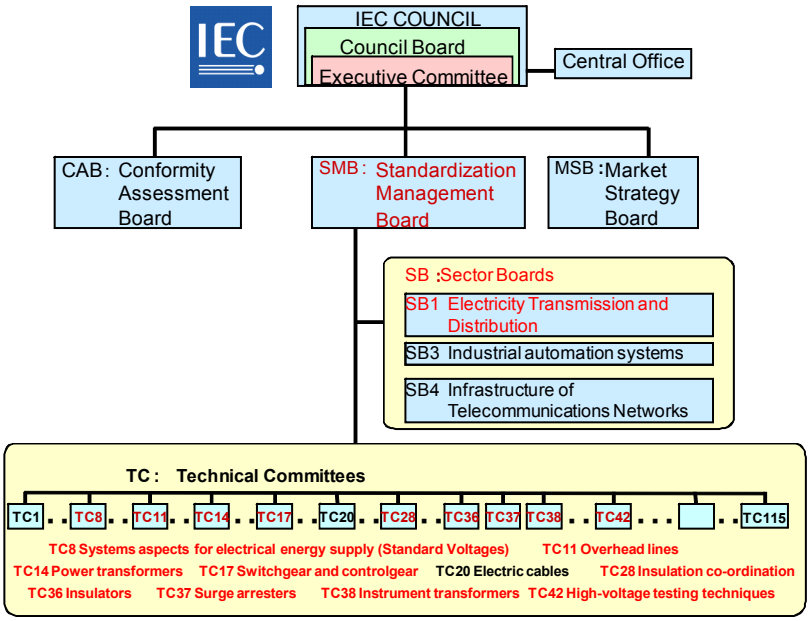


Fig. 1. Schematic IEC organization related to UHV standardization

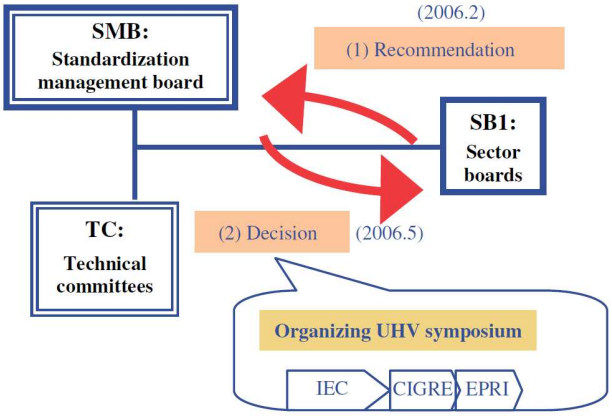
(2) First step of UHV standardization

In 2005, five years ago, it was expected that the pilot project of 1100 kV UHV transmission would operate in China by the end of 2008. UHV engineers and researchers have felt growing requirements for standardization of UHV technologies.

Under the encouragement of such requirements, SB1 held the first SB1 Asian members meeting in November 2005. The IEC standardization of the UHV technology was discussed at the meeting. The SB1 Asian members meeting is generally scheduled midway between two successive SB1 meetings. The reason comes from the fact that Asian members cannot always attend the SB1 meeting although the Asian market, especially the Chinese market, becomes large and important in a transmission and distribution field.

The discussion points of the SB1 Asian members meeting about the UHV standardization were proposed to the SB1 meeting held in February 2006. After discussions the SB1 meeting agreed to send a recommendation of the UHV standardization to the SMB.

In the SMB meeting held in May 2006, the SMB agreed to recognize needs for UHV transmission standards but decided to hold a symposium in order to investigate the present situation. The SMB required the symposium to offer clear answers to questions from the SMB: maturity of UHV technologies and market needs for UHV standards. Those initial processes are shown in Fig. 2.



holding UHV symposium

(3) IEC-CIGRE symposium on UHV

Following the SMB's decision, Chinese delegates promptly proposed to hold the symposium in their country. The IEC central office requested the SB1 to collaborate with CIGRE for the symposium organization. It was agreed that the organizing committee of the symposium should be jointly operated by IEC and CIGRE, China should form a local committee, and the SB1 should promote all preparatory work in IEC. The technical program of the symposium was originally discussed and made at the second SB1 Asian members meeting in June 2006. Then it was sent to both IEC and CIGRE.

To watch these processes and lead the international standardization activities, the Japanese Electrotechnical Committee (JEC) in IEEJ decided to establish a new committee, the International Standardization Committee

on UHV System (chair: K. Hidaka), on Dec. 2006. The new committee contributed to make a detailed technical program, whose original program had been proposed by IEC-CIGRE collaboration activity. The program was finally approved and the call for papers was issued based on the program. On the call for papers, there were many papers submitted from around the world.

Almost one year after the SMB's decision, the Beijing UHV symposium took place successfully in July 2007. This symposium confirmed a strong market needs for the UHV standardization and maturity of the UHV technology. And also the symposium declared to give first priority to 1100 kV AC system. Closing remarks of the symposium noted that the joint IEC-CIGRE coordination group should be started as soon as possible by being accepted by the SMB.

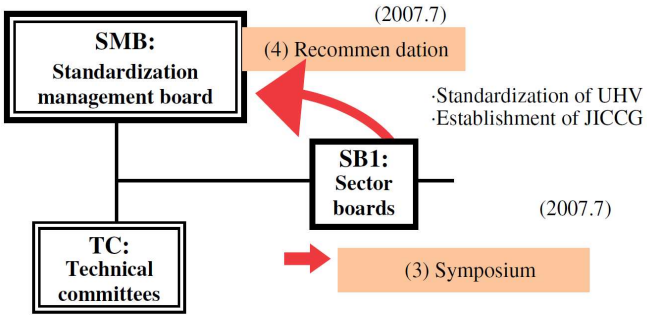


Fig. 3. Process after UHV symposium held in Beijing

The SB1 reported clear answer from the symposium to the SMB. At the same time, the SB1 made a recommendation for the necessity of establishing a joint IEC-CIGRE coordination group (JICCG) for the standardization to the SMB. The SMB approved the recommendation at the meeting in October 2007. At this moment, the UHV standardization was given a 'go' sign. The process is schematically shown in Fig. 3.

(4) Joint IEC-CIGRE coordination group (JICCG)

According to the SMB approval of the SB1 recommendation, the JICCG started in November 2007. The objectives of the JICCG are as follows: First, to determine the domains in UHV technology, both AC and DC, secondly, to make recommendations for what UHV standards the market requires and to develop strategies for international standardization of UHV technologies, thirdly, to prepare a road map of standardization of UHV technologies with full cooperation between CIGRE and IEC.

About 15 members of the JICCG are selected through the IEC and the CIGRE. The road map for the UHV AC standardization was discussed at the JICCG meeting (see Fig. 4). There are three steps. At first, horizontal standard committees such as TC 8 and TC28, start operations. Subsequently, some equipment standard committees such as TC 14 TC 17, and TC 37, begin to make a draft of standard. Finally, other equipment standard committees start.

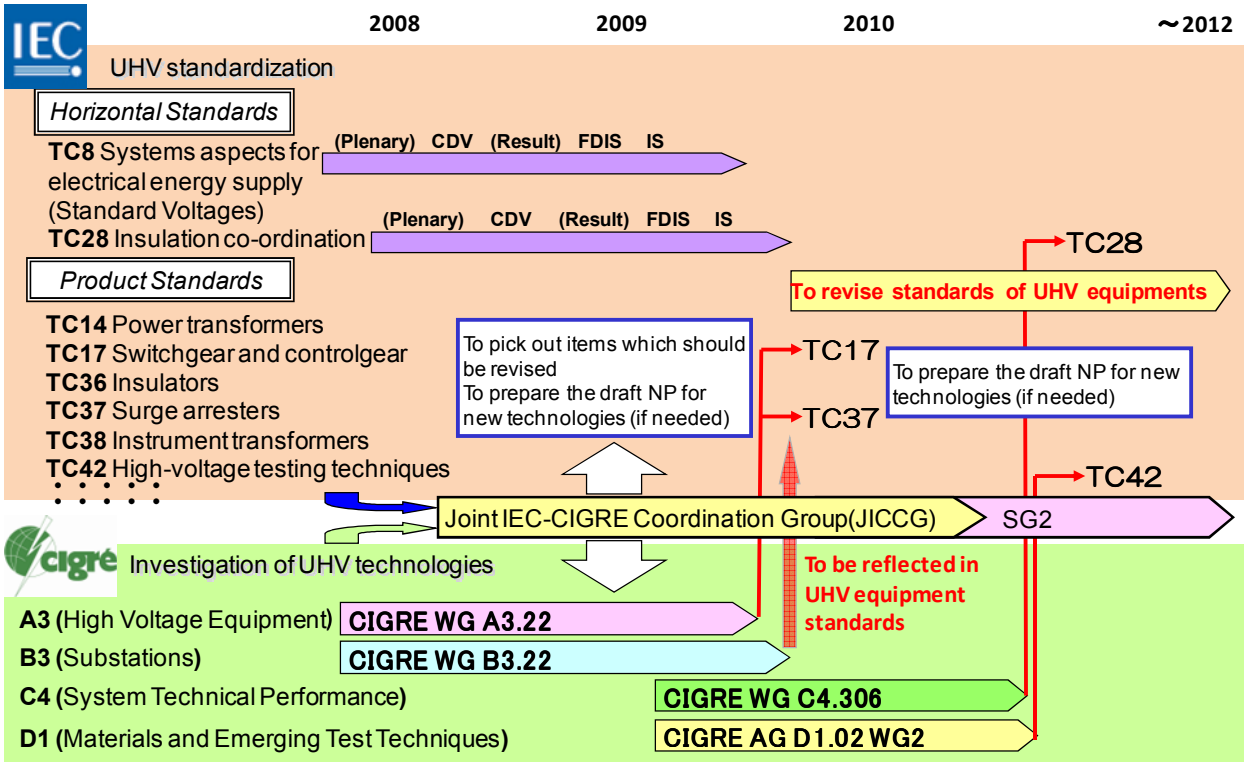


Fig. 4. ROAD MAP of Standardization on UHV AC Technologies

(5) 1100kV UHV as standard voltage

The Committee Draft for Vote (CDV) on the standard voltage compiled by TC 8 was approved in 2008. It was followed by the Final Draft of International Standard (FDIS) whose vote was closed on 22nd of May, 2009. Accord-ing the result of voting, 1100 kV was approved as one of standard voltage values in IEC 60038. Now, 1100 kV is listed in the table of AC three-phase systems having a highest voltage for equipment as shown in Table I.

Table I. AC three-phase systems having a highest voltage for equipment exceeding 245 kV (IEC 60038)

Highest voltage for equipment kV
(300)
362
420
550[b]
800[c]
1 100
1 200

[a] The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in future. The values are voltages between phases.

[b] The value 525 kV is also used.

[c] The value 765 kV is also used; the test values for equipment should be the same as defined by the IEC for 765 kV.

IEC 60038

As to the standard rated withstand voltage (the testing voltage) in electrical insulation coordination, the CDV was approved in April 2009 and the FDIS was finally approved on 30th of October, 2009. Table II shows the standard rated withstand voltages for switching and lightning impulse waveforms including the highest voltage of 1100 kV in IEC 60071-1.

A series of activities toward the international standardization have been discussed and carried out by the members of the IEEJ International Standardization Committee on UHV System which is characterized by working horizontally across fields of systems and products.

Table II. Standard insulation levels for equipment exceeding 245 kV (IEC 60071-1)

Highest voltage for equipment U_m kV (r.m.s. value)	Standard rated switching impulse withstand voltage			Standard rated lightning impulse withstand voltage kV (peak value)
	Longitudinal insulation kV (peak value)	Phase-to-earth kV (peak value)	Phase-to-phase (ratio to the phase-to-earth peak value)	
1100	-	1425 (4)	-	1950
				2100
	1425	1550	1,70	2100
				2250
	1550	1675	1,65	2250
				2400
	1675	1800	1.6	2400
				2550
1200 (5)	1550	1675	1,70	2100
				2250
	1675	1800	1,65	2250
				2400
	1800	1950	1,60	2550
				2700

(6) Present and future works

In China, the commercial operation of the UHV transmission system, whose test bases had been completed in 2007[4], started on January 2009.

In 2009, the SMB requested the JICCG to start the following works: first, to carry out 2nd and 3rd steps of UHV AC road map, secondly, to pay special attention for 1200kV, thirdly, to coordinate among TCs for UHV DC.

By the end of 2009, the SMB decided that Strategic Group 2 (SG2), which was newly formed, collaborated in a short term with the JICCG, and later took over the JICCG's works in order to promote the international standardization of UHV technologies.

The equipment standards are being discussed in related TCs in the IEC based on the reports which the CIGRE task groups compiled in 2009.

4. Conclusion

The international standardization activities mentioned in this article depend mainly on the Japanese renowned and advanced 1100 kV UHV technology. This fact would have an influence on future activity in the international standardization.

The author would like to stress again that Japan and East Asia countries should collaborate more and more to transfer their splendid technologies to the world and to take the initiative in setting the international standards on the technologies.

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