Fundamental Concepts of Environmental Testing Techniques in Electricity and Electronics Part 3: Testing standards

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In this issue, we are going to consider various items within public environmental testing standards. We shall take the IEC as an example, considering its structure and its process leading up to the establishment of testing standards, the characteristics of those standards, their current applications, and a summary of environmental classifications. We will not touch upon the details of individual standards, but we will be happy if this article serves as an aid in considering how to effectively apply the testing standards by understanding the process involved in their creation.

Contents

1. Introduction (positioning of testing standards)

In today's marketplace, industrial products are subject to an enormously wide range of environments that have become increasingly complex, making it impossible to apply uniform testing standards to all industrial products or to enforce common testing methods. However, the number of fundamental environmental factors is limited, and by combining these various factors and by selecting and combining their severity, we can create modified testing conditions that can be applied for individual testing. And yet, even within these conditions, average testing conditions do exist, and we must be able to show results quantitatively and be able to guarantee that anyone carrying out this testing based on the same standards will achieve similar evaluations and results. For these reasons, efforts to standardize test method are progressing on a global scope.

To consider this historically, GATT (the General Agreement on Tariffs and Trade Standard Code) came into effect in 1980 and set up various standardization agencies of the signatory nations to eliminate unnecessary barriers to mutual trade in regulations, standards, and systems of proof established in the field of technology. This approach promoted the establishment of international standards from the standpoint of promoting international free trade.

From 1990, this mantle was passed on to the WTO (World Trade Organization), leading to more importance being placed on international standards. The type of matters subject to review by this international body increased dramatically at that time, and evolved from being concerned merely with such fundamental matters as terms, basic standards, and product standards, to overseeing reliability management as well as safety and environmental problems.

Within this movement toward international standardization, the ISO9000 series enacted in 1987 had an especially pronounced effect on industry with its quality assurance system for industrial products. These standards are currently being adopted by more than 70 countries worldwide. In Japan as well, companies in a wide variety of fields, from industrial manufacturing to banks and securities firms, are enthusiastically rushing en masse to acquire the ISO9000 certification.

Within the arena of electrical and electronic industrial products, every country involved conforms to the IEC standards for domestic standardization of consumer products that are subject to these standards. The various countries of Europe in particular have been actively incorporating the IEC standards into their own domestic

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standards from their inception. CENELEC (the European Committee for Electrotechnical Standardization) and ETSI (the European Telecommunication Standards Institute) have incorporated the IEC standards since 1994.

Since the toppling of the "Berlin wall", the U.S. has stopped developing new MIL standards, and recently has been energetically promoting a variety of IEC activities.

In Japan, environmental testing was initially created mainly using the U.S. MIL standards as a model, but in coordination with the changes in the recent global situation, the Ministry of International Trade and Industry (MITI) has been promoting conformance between the JIS (Japan Industrial Standards) and international standards. Since 1993, work has been in progress to replace JIS standards, including both new and pre-existing standards, with translations of the IEC standards almost without changes to conform to the international standards.

In Part 3, we will look at the organization of the IEC and summarize the process of creating standards, focusing on how those activities are carried out. At this point, we will not touch directly on the details of individual standards, but we hope that each of you will independently take a look at the testing standards that affect you.

2. Structure for establishing testing standards

How are testing standards established and promulgated? Using the IEC standards as a model, we shall look at the organization and the process for establishing standards. The sequence explained here may not always be exactly the same for other public standards or industrial and private standards, but in general it can be assumed that most standards are enacted by going

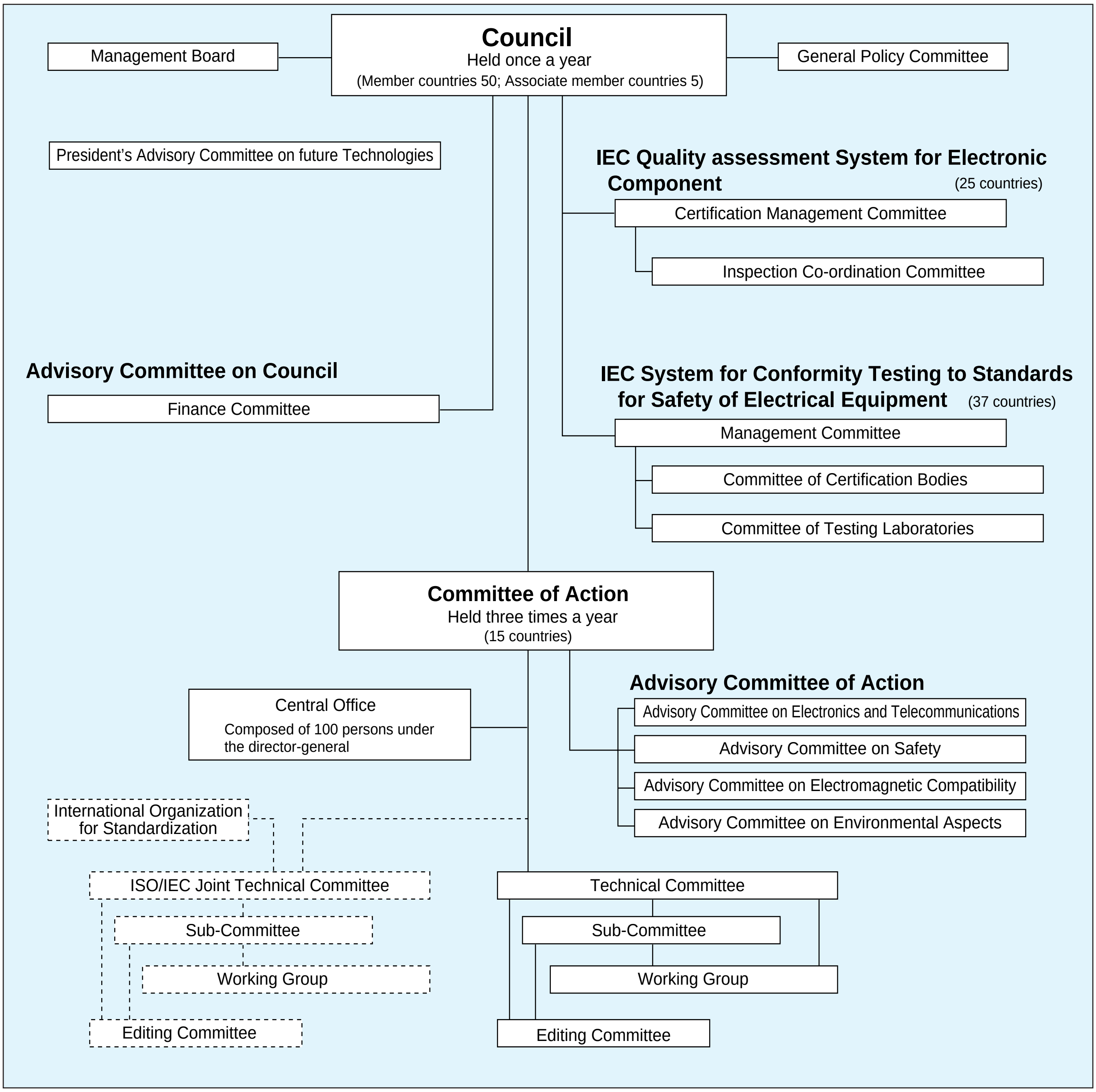

Fig. 1 International Electrotechnical Commission (IEC)

through the same type of process outlined here.

The duties of the IEC (International Electrotechnical Commission) are stated in their General Information as follows.

"The mission of the International Electrotechnical Commission (IEC) is to promote, through its members, international co-operation on all questions of standardization and related matters, such as the assessment of conformity to standards, in the field of electricity, electronics and related technologies. It therefore provides a forum for the preparation and implementation of consensus-based voluntary international standards, facilitating international trade in its field and helping to meet expectations for an improved quality of life."

These duties are achieved through the publication of materials (including international standards and recommendations in a form for international standards). When creating domestic standards, each country is asked to use the IEC standards as far as the domestic situation will allow. The IEC has no legal standing as a governmental organization, but rather is ranked as a corporation.

The IEC bureau was first located in London, England, a member country at the inauguration of the IEC, and then was moved to Geneva, Switzerland in 1947. In November 1967, the IEC and the ISO (International Organization for Standardization) formed a joint technical committee, leading to the close cooperation that exists today between the two organizations.

Within the present field of industrial products, the IEC retains control of standardizing the field of electrical and electronic products. In 1982 the IECQ (IEC Quality Assessment System for Electric Components) and in 1985 the IECEE (IEC System for Conformity Testing to Standards for Safety of Electrical Equipment) began to be used as assurance systems.

Member country to the IEC each forms a national committee which is required for representing its national electrical and electronics organizations (manufacturers, users, government agencies, academic societies, and industrial organizations). Each country is then authorized to have only one agency qualified as a committee member. In Japan, the JISC*1 (Japanese Industrial Standards Committee) is designated as the committee

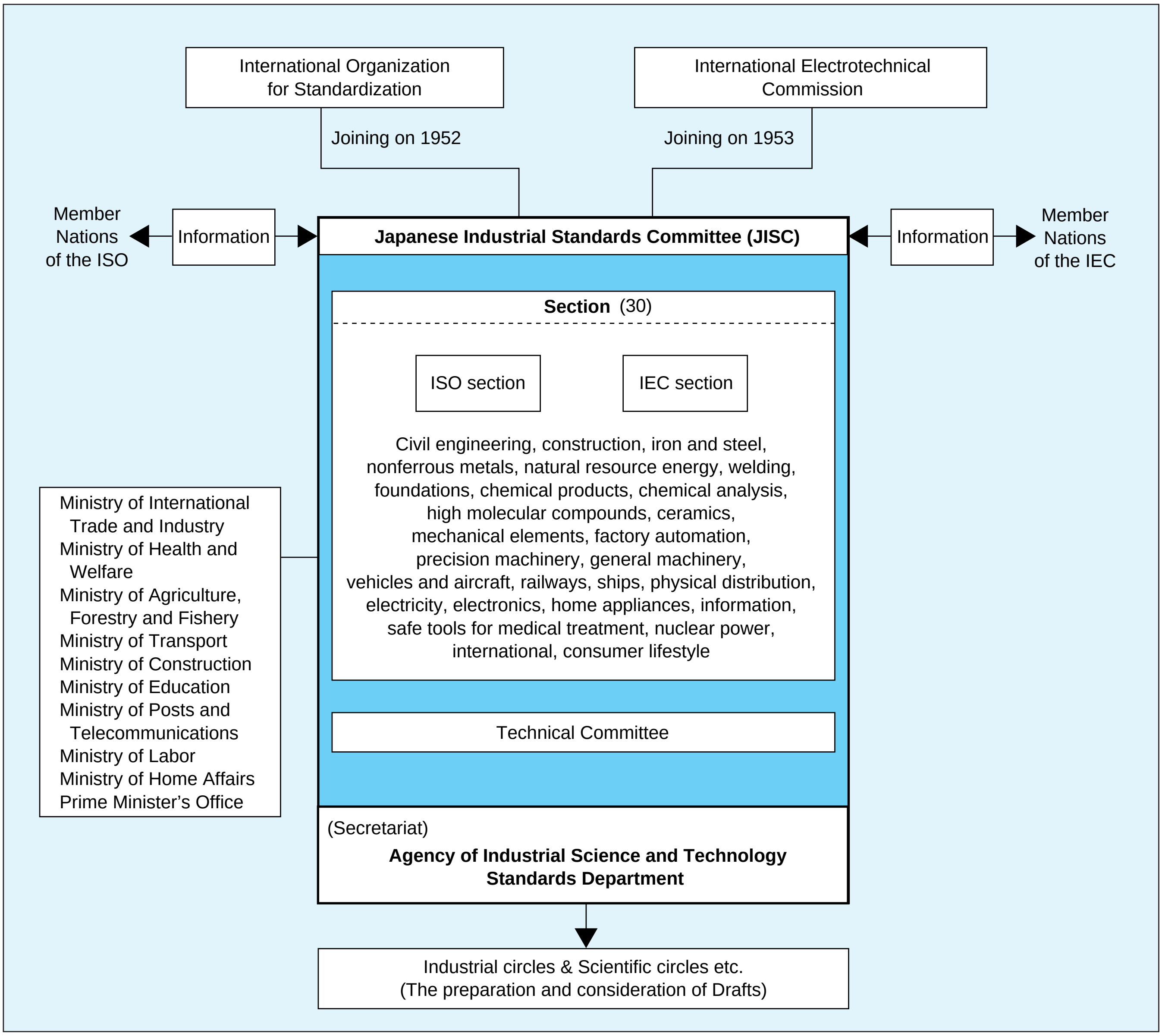

Fig. 2 The Organization for Standardization of Japan

member, and the Standards Department of the Agency of Industrial Science and Technology in the Ministry of International Trade and Industry, is in charge of the committee.

The revenue for the IEC comes from the annual share of expenses from each country, sales of publications, and other approved plenary sessions.

The official languages for activities of the IEC are English, French, and Russian, but in actual practice English is usually used, and standards and technical reports are currently drawn up in English and then translated into French for publication. In Russia, the Russian Federation National Committee independently publishes Russian-language editions.

The IEC is organized roughly as seen in Fig. 1, and the country currently holding the presidency is the United States of America. Currently, as of March 1998, there are 50 member countries. Within Japan, the Organization for Standardization is organized as shown in Fig. 2.

3. Process of creating IEC standards (Development of international standards)

Within the structure of the IEC, the groups directly concerned with creating testing standards are the TCs (Technical Committees) that handle technical matters. TCs are created for each specialized field, and there are now approximately 80 to 90 TCs. Within those committees, special SCs (Sub-Committees) are formed as needed. WGs (Working Groups) are formed as necessary to review pre-existing standards and create the drafts for new standards. Special ADs (Ad hoc Groups) are set up to handle limited problems.

Proposals for standards are drawn up within each committee (i.e., in the TC, SC, or WG) and these project stages are developed as shown in Table 1, and the order given in Fig. 3.

At this point, let's look at the individual steps leading up to the creation of standards.

Table 1 Project stages and associated documents

Project stage	Associated document	
	Name	Abbreviation
0 Preliminary stage	Preliminary work item	PWI
1 Proposal stage	New work item proposal	NP
2 Preparatory stage	Working draft(s)	WD
3 Committee stage	Committee draft(s)	CD
4 Enquiry stage	Commitee Draft for Vote	CDV
5 Approval stage	Draft International Standard	FDIS
6 Publication stage	International Standard	

Preliminary stage

This stage is for handling the latest technology that doesn't lie within the administrative range of the TC or the SC. Preparations are made at this point for technology that doesn't require immediate standardization.

Proposal stage

Proposals for New Work Items that currently lie within the administrative range of the TC or SC are begun at this stage. Proposals may be made by any of the following.

- Any national body
- The secretariat of that technical committee or sub-committee
- Another technical committee or sub-committee
- An organization in liaison
- The Technical Management Board or one of its advisory committees
- The Chief Executive Officer

Normally, most proposals are made by a particular country. In fact, the country proposing to create a standard will have already drawn up the gist of the details serving as the basis for the proposal, and then will submit the proposal to the appropriate TC or SC. A written form is sent to countries participating in that TC or SC asking whether they want to use the proposal. These voting sheets are collected within 3 months. If a majority of countries approve the proposal, and at least five countries participate in the work of drawing up the draft of the standard, the proposal is approved and is formally adopted. When necessary, a WG is formed and a target date is set for completing the working draft. Experts appropriate to the details of the proposal are recruited to serve in the WG from among member countries participating in the TC or SC.

Preparatory stage

The experts of each country hold WG meetings about twice a year and brainstorm the concrete points and specifics of the original draft. During this time, all matters are discussed in the WG, technical investigations are carried out, and meetings are held for further study of the data. Finally, the WG gets their working draft (WD) ready and submits it to the committee to which they are attached.

Committee stage

The WD received by the committee is sent on as the Committee Draft (CD). The countries participating in the TC or SC attach the opinions of their own country to the CD, which serves to express their approval or disapproval. However, at this point, there are still sections that concern domestic circumstances of each country as well as sections in the CD that are unclear, and pro and con opinions erupt in regard to individual items or even the contents of the entire proposal.

Ultimately, these opinions are sent through the committee to the WG that drew up the draft, and new discussions are requested as the WD goes back to the WG. Once again, the WG presents the revised draft based on the results of the WG discussions, and again it is sent on to each country. This cycle is repeated a number of times in creating the draft of the standard.

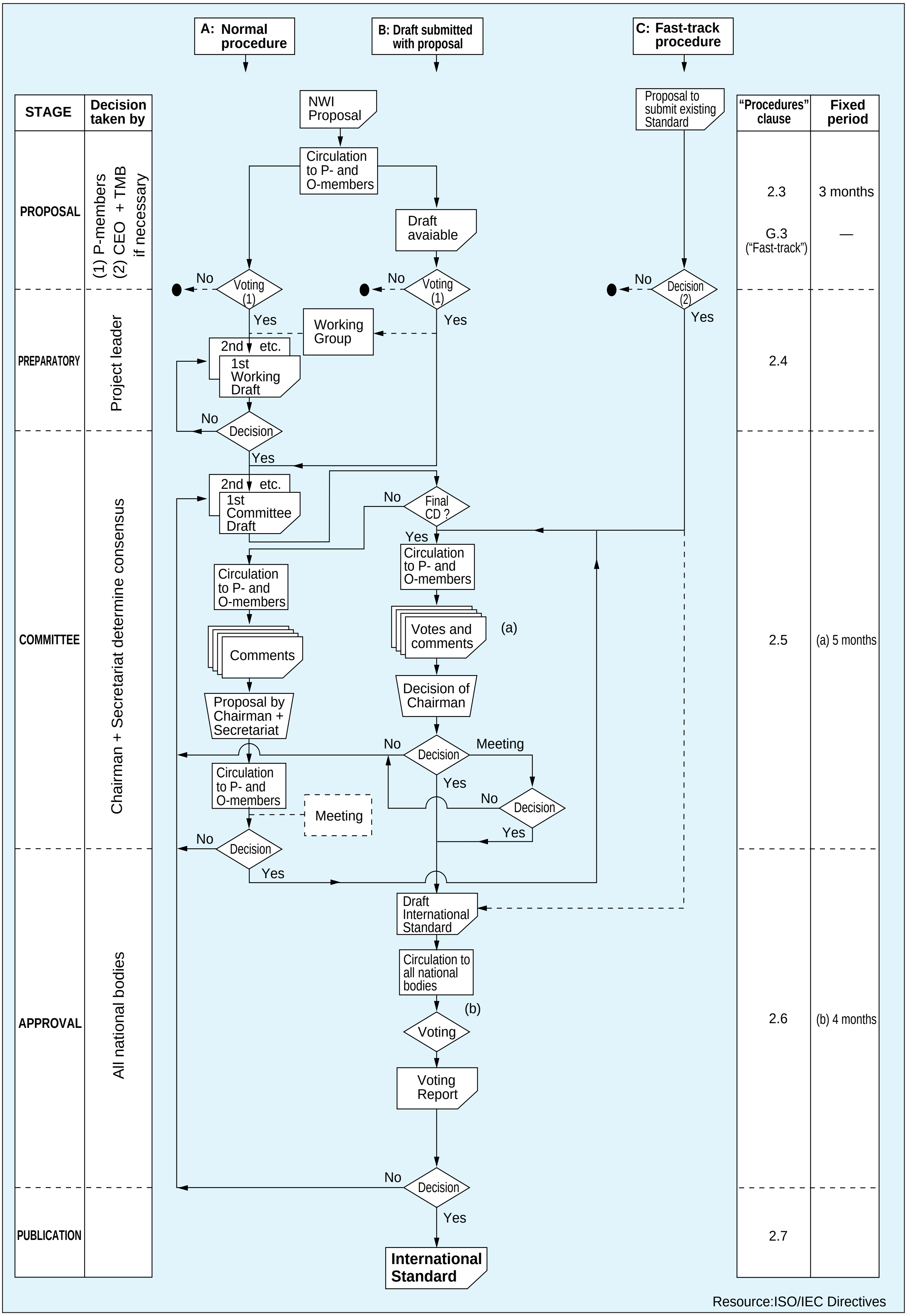

Fig. 3 Flowchart for development of an International Standard

Enquiry stage

Before moving to the Approval stage, the draft is sent to the P-member*2 countries of the TC or SC for the Committee Draft for Vote (CDV). Voting takes five months. The draft is approved by a two-thirds approval vote if the no vote doesn't exceed one-fourth. At this stage, voting countries can still express their opinions, but there is little probability that the opinions will affect the main character of the standard. If approval is attained, the revised draft is sent to the Central Office within four months. Here, the draft is used to create the final draft, called the Final DIS (FDIS), in accord with the standards form.

Approval stage

The draft that has become an FDIS is sent to each country to receive final approval in voting that takes two months. If nothing major comes up at this stage, the individual countries are not allowed to give their opinions on the contents of the draft. Comments are limited to pointing out problems in editing. Standards for approval or rejection are the same as in the Enquiry stage.

Publication stage

If the requisite majority approves the FDIS, authorization is given to publish the proposal as a formal international standard. The Central Office is in charge of administrative work up to publishing, and the form as an international standard is usually prepared within two months. The published standard is reviewed at least every five years by the TC or SC in charge. A majority vote of the P-members is required to continue the standard, revise it, or abolish it. If the committee decides to revise the standard, it becomes a new project and follows the same sequence as when creating a new standard. Other regulatory details exist for abolishing the standard. (In this way, other regulatory details exist for IEC administrative guidance.)

Within this sequence, the WG stage requires the greatest time and expense. In particular, when problems exist with each of the experts participating in the WG, they occur at the following two points.

Let's look at the economic problem first. We mentioned that the meetings are held about twice a year. Experts from normally participating countries currently attend the meetings on a voluntary basis. For members of participating countries who must travel a long way to where the meeting is held, this means a heavy financial burden from such expenses as travel fees and lodging. Meetings of the WG handling environmental testing matters are usually held in Europe, placing a financial burden on participating members from countries in Asia in particular. If the meetings were held in Asia, the reverse would be true. Very little aid is given from attached countries at the WG level, and at present most of the expenses of sending the experts abroad are borne by the corporations to which they belong. The current problem, therefore, is that most who are not employed by relatively affluent corporations cannot attend. Participation is possible as a corresponding member through such measures as letters and faxes, but it is difficult to transmit one's actual intentions, creating a rather large probability of a situation similar to trial in absentia.

The other problem is one of time. The CD, which is the WG draft that takes the most time, is sent to each country for a period of gathering opinions. If the details of the main points can be fully worked out in the WG, there will normally be few issues contended at the CD stage. However, even if the logic of the draft stands up well in interdisciplinary and logical terms, if it contains little of practical value, it will cause continuous objections, and generally will not win approval by the various countries no matter how much time is taken. Items exist which have been under consideration at the WG level for more than 10 years without being able to reach the final draft stage. If this state of affairs continues, it will not be unusual in this age of swift technological progress for the peak period for a technology to have already passed before agreement can be reached on the standard. Due to the tendency for this type of problem to occur, the IEC is trying to speed up the process at each stage, but so far has been unable to make much progress, due to the differing situations in the various countries.

4. Characteristics of standard testing methods

To begin with, public standards such as those of the IEC have a strong character of mutual agreement. However, seen as industrial standards, they also have the aspect of products with great compromises. Therefore, many sectors cannot really be said to purely scientific in their handling of technical problems. It seems necessary to see those items as reflecting the occasional international situation as well as the domestic governmental and economic situations of the various countries. Scientifically speaking, this type of situation leads to a number of points of contradiction at present.

The testing standards of the IEC present test conditions from a completely objective standpoint, and do not directly participate in any other purposes. In other words, they never touch on the individual products that are tested. That is why it cannot be guaranteed that the technical information was obtained according to the merits and demerits of the product as indicated through testing according to the testing conditions in the individual testing standards. Standard tests are simply tools to achieve specific purposes, and how those tests are used (e.g., including whether they are used a standard for determining product acceptability) is left up to the user. We must be aware that the standard itself was created with no relationship to the results of the tests.

The environmental testing methods standardized by the IEC are appropriate for handling most electrical and electronic consumer products, but when the products are subject to the effects of complex environments, severe problems crop up in combining tests, adding on, repeating, and in testing sequence. Contracts must be exchanged in advance based on mutual consent between the user and the supplier of the products and proper conditions must be set for how these test methods are used. (Giving priority to the test conditions required by individual products is also authorized within IEC standards.)

5. Current applications of testing standards

We have already stated that when deciding to carry out testing, the objectives of the test must be determined in advance. This is not all there is to it. It is also important to be aware of patterns obtained corresponding to various purposes in selecting the testing method. If we confuse the purpose with the result when carrying out a test, the test will serve no purpose at all. Of course, we must also be well aware of the limits of the test itself. (We cannot expect data for long-term guarantee of the product as it is used in the actual conditions within the marketplace environment.) However, "Fixed menu type" tests within the standards can be repeated as prescribed. If the complaint is made that the test doesn't serve a useful purpose, it is because the ability of the testers themselves is being tested.

At this point, let's classify tests according to their major purposes, which can be separated into the following categories:

(1) Finding and correcting technical problems,
(2) Determining or comparing product merits or demerits, and
(3) Seeking concrete reliability.

Standard testing methods can be used for numbers (1) and (3), but there is a high probability that in reality contents of the test would be extremely individual (or individualistic) based on independent conditions. Therefore, we would not expect the tests to have a common quality. Category (2) has the strongest relationship to standard testing. Representative tests in this category include all types of certification testing, acceptance testing, and tests for delivery and shipping. In other words, these tests are for accepting or rejecting and all are fixed-form (fixed menu style) and are performed to determine whether the product meets the standard level of quality. Determination of factors related to the standards and test conditions in general use for such tests such as the stress severity, time, and the number of samples removed should all be mutually agreed upon in advance via contract. If we take these tests as representative of the level of the greatest common denominator for transactions between users and manufacturers, then passing this test can provide wide public acceptance. However, we must be aware that this does not indicate individual product reliability.

At first glance, standard testing seems to have the possibility for wide public application, but when applying the tests strictly in the prescribed form, they are unexpectedly limited. At least in private corporations, at present these public standards are looked at from the corner of the eye while individually carrying out tests under independently determined test conditions. (In general, these conditions are much more severe than public standard tests.) In addition, each corporation maintains its own private standards based on its own policies, and such standards usually prescribe conditions with a much higher level of stress than do the public standards.

6. Environmental classifications in IEC standards

Up to this point we have looked at the structure and flow involved in establishing environmental testing standards, and also the current method of applying these standards. Now let's see what type of classifications are made for the "environment" within the testing standards. Below is a brief outline.

In the IEC, the 60721 series standards contain the following overall divisions.

Part 1:
Types of environmental conditions and representative values

Part 2:
These standards explain natural conditions, classify environments based on over 10 years of meteorological data, and also give a general explanation of how the environments affect the products. Fire is also prescribed as a special condition environment.

Part 3:
Environmental conditions which the products encounter (e.g., storage, shipping, indoors, outdoors, vehicles, ships, carrying, and mines) are classified and given symbols.

Next is a list of the environmental conditions and factors covered.

(1) Meteorological conditions: temperature, humidity, pressure, wind, precipitation, radiation, and water other than rain.
(2) Biological conditions: flora, fauna
(3) Chemically active substances: NaCl, SO_2, H_2O, NOx, O_3, NH_3, Cl, HCl, HF
(4) Mechanically active substances: sand, dust, soot
(5) Polluting substances: all types of oil, electrolytes
(6) Mechanical conditions: vibration, falling, shock, inversion, acceleration, angular motion

Next, we would like to touch briefly on meteorological data, which of all these conditions has the strongest relationship to environmental testing.

The IEC60721-2 series consists of technical data, indicating the influence each natural environmental condition has on products, and also presents worldwide meteorological data. In 1995 the IEC60721-2-1 standard was adopted as JIS standard. (JISC0111: Classification of environmental conditions. Part 2: Environmental conditions appearing in nature. Temperature and humidity) This standard contains statistical values of meteorological data from every region of the world. For statistical values of temperature, this standard presents absolute extreme values, average temperatures of extreme values for the year, and average temperatures for daily averages of extreme values for the year. In addition, the standard divides climate into four classifications and then classifies the regions of the world into nine forms based on the type of climate. (Refer to Fig. 4 and 5.) Further, the standard presents a geographical survey of open-air climates, which adds temperature and humidity factors to the above statistical values in each classification.

According to these classifications, the Japanese climates are moderate open-air climates (which include cold temperature, warm temperature, warm dry, and mild warm dry climates). The climate forms include cold temperature for Hokkaido, with the rest of Japan classified as either mild warm dry or warm damp. The new classification of tropical region has recently been added to meteorological conditions, and more revisions can be expected before long. The tropical regions are regions inside the tropical regression lines (the tropic of Cancer to the north and the tropic of Capricorn to the south). The meteorological conditions in these regions include moderate regions, dry desert regions, pluvial and damp regions, as well as high-altitude regions 4000 meters above sea level and up such as the Andes and Kilimanjaro. Those environmental classifications are extremely diverse.

Finally, we would like to present the recent trends in IEC activities related to environmental testing. From 1997, the previous TC50 dealing with environmental testing methods and the previous TC75 dealing with environmental classification were combined to form the new TC104*3, which will carry on the work of both prior TCs. Within the continued items, the relevant guidance will be completed for both the IEC60721 series of prescribed environmental conditions, and the IEC60068 series of prescribed environmental testing methods, and can be considered extremely useful for selecting testing methods.

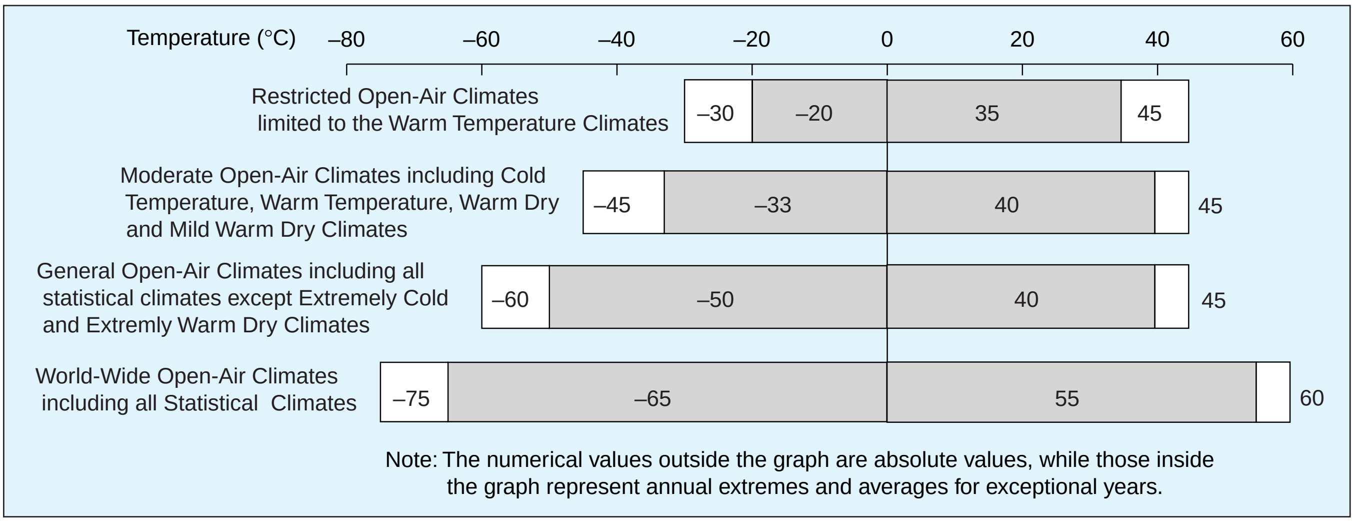

Fig. 4 Temperature conditions of climate groups

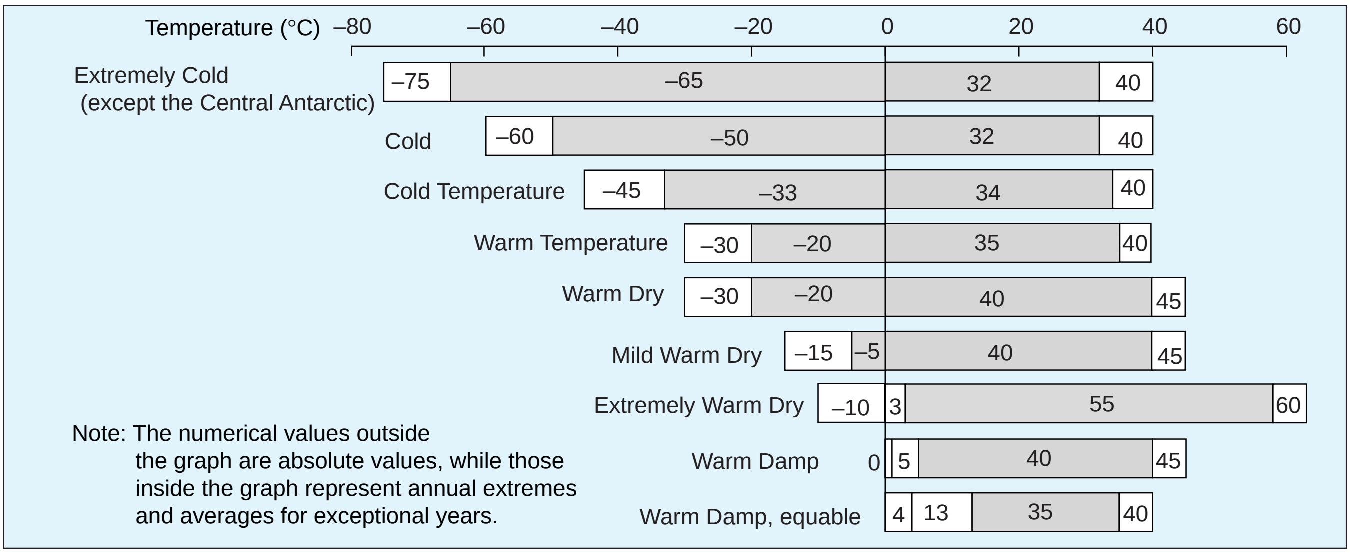

Fig. 5 Climate types and temperature conditions

Terminology

*1 **JISC**: Japanese Industrial Standards Committee
JISC is within the Ministry of International Trade and the Industry-Agency of Industrial Science and Technology, and is involved in investigative deliberations on establishing, revising, and abolishing Japanese industrial standards and specifying what items should display the JIS symbols. In addition, they are able to submit reports on suggestions to advise the related ministries on matters related to promulgating industrial standardization. This committee utilizes 29 sectional meetings and around 1,000 specialists and is composed of 240 committee members from academic backgrounds, and around 8,000 provisional members and specialist members.

*2 **P-member**
Participating actively in the work, with an obligation to vote on all questions formally submitted for voting within the technical committee or sub-committee and voting on drafts of International Standards, and, whenever possible, participating in meetings.

*3 **TC-104**
Environmental conditions, classification, and methods of testing