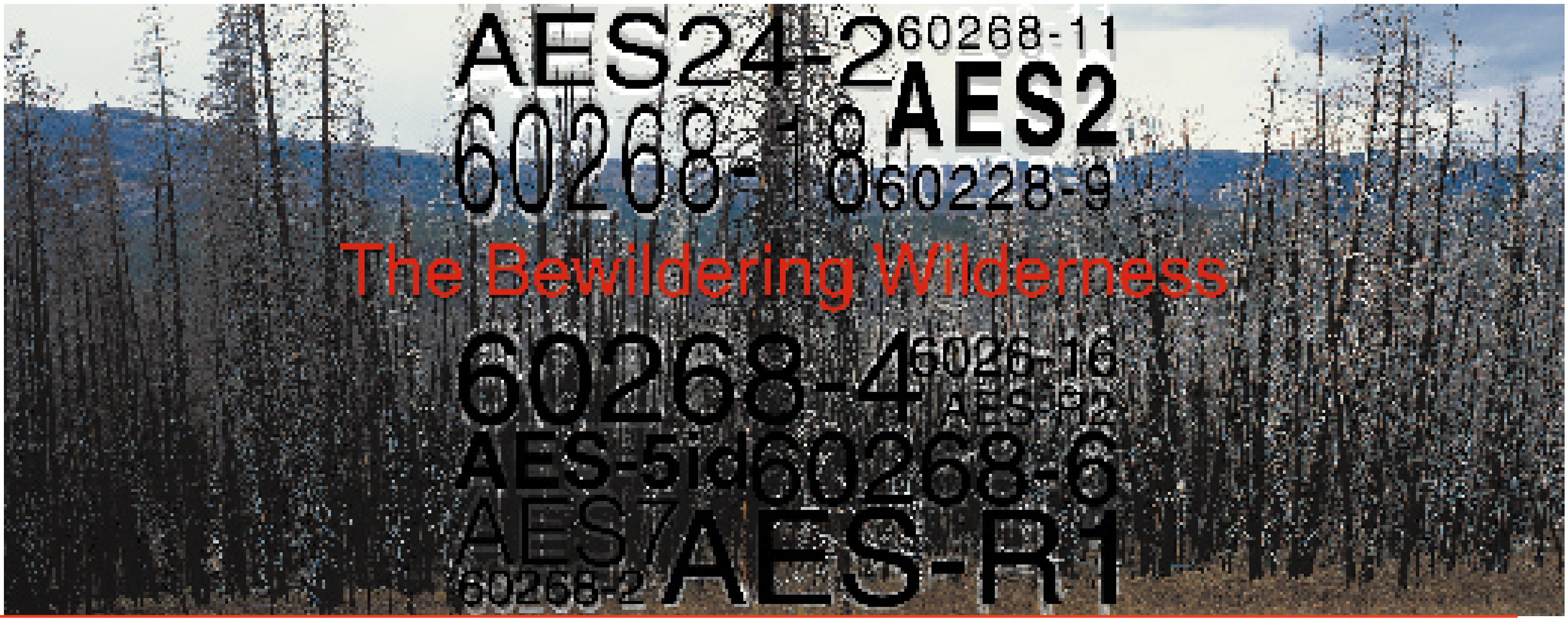

The Bewildering Wilderness

Navigating the complicated and frustrating world of audio standards.

By Dennis A. Bohn

While researching a different article, certain discoveries both surprised and disappointed me. This is often my experience in navigating the bewildering and sooty trails of the audio standards wilderness only to emerge from that jungle not knowing which is more frustrating, trying to find an audio standard or discovering after you found it that it is useless. Certain performance specs are common to every audio product. The application does not matter. All audio products are graded by their noise level, distortion products, frequency response, dynamic range, maximum output and how much signal leaks into unwanted channels. Admittedly, there are lots of other specifications unique to certain product families and categories, but the preceding represent the classic core audio measurements, whether used for the production or reproduction of audio, found in your place of education, work, worship or entertainment, in your cell phone, computer or Internet appliance, or travels in your ship, airplane or car. It is in trying to find the standards that specify measurement conditions that prompted this article. I offer my apologies for the many initialisms used; such is the way of standards organizations. See "Websites for audio standards," page 63, for full names and websites.

Simple beginnings

It starts with the question, "Are there audio standards that cover such and such?" In this case, it was the classic measurements mentioned above. Quickly, you will discover that it is nearly impossible to find information about audio standards. No place was found capable of answering the basic questions of whether a standard existed, where to find it and how much it costs, and these questions need answers more simple than those in existence today.

Weeks passed while I e-mailed and surfed the Internet for the answer, but I had no luck. Neither instrumentation manufacturers, audio organizations nor experienced audio designers provided a solution. My e-mail, for the most part, went unanswered. Apparently, some felt that such a simple question did not warrant an answer, which hinted at the elitist attitude: We have the standards; you don't, and, therefore you need us.

In the end, I found no useful standards. There were no official documents specifying the testing conditions—what frequencies to use, what levels to set, what bandwidths to measure. I discovered no answer to these simple and basic questions about core audio measurements. Although IEC 60268 Sound System Equipment, a standard in 18 parts, is supposed to cover exactly what was being sought, it is really too general.

Experienced designers may know how to do these tests, but no one has the standards or, perhaps, has ever even seen them. Strangely, everyone knows how to do them. Thus, we have a great oral tradition of testing whereby each new generation is taught by the preceding generation. When manufacturers differ regarding the specifics, however, then someone must produce the standards or know with confidence that no such standards exist and, consequently, create them. The great oral tradition will eventually break down and result in manufacturers' measuring and reporting in different ways. In short, the whole reason standards exist in the first place is to prevent this exact problem.

The difficulty, however, does not stop there. Try finding the standard for the CCIR-468 noise filter (now the ITU-R 468 noise filter) or a copy of the CCIF IM test (which, apparently, has disappeared). Some still refer to the IHF-201 testing standard for power amps, which is now EIA RS-490, but it seems that there is no readily accessibly means of discovering that. Moreover, manufacturers of graphic EQs and real-time analyzers may proclaim that their filters are located on ISO centers. Which ISO standard is that? Few know, and fewer still could find it if challenged. For those taking notes, it is ISO 266.

Many people work hard at creating standards, but equally hard work is needed to make the results known and easily accessible. It seems as though we have lost sight of the forest for the trees. Before it is over—if you survive the distance—you will face some inevitable truths about audio standards, which are that they are hard to find, created by too many different organizations (15 or more, resulting in confusion and conflicts among them), prolific in nature (one standard references four that reference 10 that reference 20 and so on), and, ultimately, expensive.

Finding the standards

Finding audio standards can make insanity seem appealing or, at least, understandable because it ranges from difficult to impossible. When it comes to audio standards, there is no such thing as an audio engineer. There are motion-picture engineers, television engineers, radio engineers, telephone engineers, telegraph engineers, broadcast engineers, telecommunication engineers, automotive engineers, electrical engineers, electronic engineers, computer engineers and recording engineers, all of whom design audio circuits and create standards. You see, audio permeates everything, and hearing is one of the more heavily used human senses. If you are an engineer doing audio and need a standard, it really depends on the subject matter. Look to the organization representing the specific field of interest. On the other hand, if you manufacturer signal processing or other audio equipment used across several industries, then the nightmare begins.

Only two books (references 1 and 2, respectively) could be found that give any information on audio standards. The first contains an excellent article by Daniel Queen, the standards manager of the AES Standards Committee, that walks you through the complete audio standards maze. Unfortunately, it is buried and lost in an out-of-print book published in 1988. Similarly, the many standardization articles written in the AES Journal (references 3, 4, 5, 6, 7, 8 and 9) are too dated to be of any value except as interesting history, but they do an excellent job of introducing the bewildering complexity of the standards making bureaucracy. The second book, with an article by Vivian Weeks, formerly of the BBC, presents a quick overview of international audio standards, mainly from a British viewpoint, then delves into a good summary of the aforementioned IEC 60268 and its many weaknesses.

Too many organizations

Unfortunately, just about everybody makes audio standards (see "Websites for audio standards," page 63). Because audio standards are found wherever audio is found, they are just about everywhere. Audio standards started out in the telephone and telegraph industries then spread quickly through the film industry to radio, the television, the automobile and the computer, which is understandable when viewed objectively. Audio is a pervasive attribute.

In 1970, the AES reported (reference 7) on 18 organizations creating audio standards. Only 11 exist in the same form. The rest are reorganized, renamed, combined, dissolved or new. Today, depending on how you count, the number is 15. It may seem as though things are getting better, but actually, they are worse. All of the merging and morphing, eliminating and creating of organizations with new abbreviations and acronyms have outpaced my ability to keep up, and much has been lost.

A few examples will highlight the confusion. ASA did not always stand just for the Acoustical Society of America; at one time, it also stood for the American Standards Association, which then became USASI (USA Standards Institute) and, finally, ANSI. Today's EIA formed from the RMA (Radio Manufacturers Association), founded in 1924. RMA became RTMA (Radio-Television Manufacturers Association), then RETMA (Radio Electronic Television Manufacturers Association) and, finally, EIA. The MRIA (Magnetic Recording Industries Association) also merged with the EIA. IHFM (Institute of High Fidelity Manufactures) became the IHF (Institute of High Fidelity), which also became part of the EIA. The IRE (Institute of Radio Engineers) merged with the AIEE (American Institute of Electrical Engineers) to become the IEEE. Is it any wonder people get confused?

International Electrotechnical Commission:

IEC 60268 Sound System Equipment
60268-1: General
60268-2: Explanation of General Terms and Calculation Methods
60268-3: Amplifiers
60268-4: Microphones
60268-5: Loudspeakers
60268-6: Auxiliary Passive Elements (Attenuators, Transformers, Filters and Equalizers)
60268-7: Headphones and Earphones
60268-8: Automatic Gain Control Devices
60268-9: Artificial Reverberation, Time Delay and Frequency Shift Equipment
60268-10: Peak Programme Level Meters (Analog)
60268-11: Application of Connectors for the Interconnection of Sound System Components
60268-12: Application of Connectors for Broadcast and Similar Use
60268-13: Listening Tests on Loudspeakers
60268-14: Circular and Elliptical Loudspeakers; Outer Frame Diameters and Mounting Dimensions
60268-15: Preferred Matching Values for the Interconnection of Sound System Components (cancelled and replaced by IEC 61938 Audio, Video and Audiovisual Systems — Interconnections and Matching Values — Preferred Matching Values of Analogue Signals)
60268-16: Objective Rating of Speech Intelligibility by Speech Transmission Index
60268-17: Standard Volume Indicators
60268-18: Peak Programme Level Meters — Digital Audio Peak Level Meter
Cost of complete set, excluding supporting documents, is $1,059.33 (March 2000); cost of supporting documents: $5,900.52.

Besides all of these different American institutes and societies, there are also the international big three—IEC, ISO and ITU. IEC, founded in 1906, is the primary world organization for establishing international electrical and electronics standards. The IEC became the electrical division of the ISO in 1947, but it retains its autonomy and is independent of the ISO. ISO was, according to its website, founded in 1947 "to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity." Excluded are all things electrical, which is the exclusive domain of the IEC. ITU, originally formed in Paris in 1865, became affiliated with the United Nations in 1947, and it covers all international telecommunication issues.

Confusion and conflicts

Different interpretation of standards to the same problem inevitably breeds confusion. Compounding matters is the likelihood that the technical and commercial interests oppose one another. Worse, many organizations produce standards with different mandates, authorities and emphases, and there is further chaos when similar topics are standardized by multiple organizations. For example, amps and loudspeakers are covered by standards issued by the EIA, IEC and AES. Which standard applies?

On top of it all, after 50 years of issuing standards, the IEC decided to add "60,000" to all of its standard numbers, numbers that have been used and referenced for decades. IEC 268, for example, became IEC 60268. Further, this change has had the unintended result of making all IEC numbers appear similar and less distinctive, thereby creating more mistakes and confusion.

Following the twists and turns of old standards passing from one organization to another is a challenge. Consider the VU meter, for example. (Incidentally, per the standard, "VU" is supposed to be in lowercase, but no one followed that requirement, so we now have a standard practice of using uppercase, and, to my knowledge, no one has ever mistaken "VU" to mean "voltage-potential energy." This is a perfect example of how standards people put themselves into a self-made box when they rule out common sense and people's natural ability to clearly understand things in specific contexts.) The VU meter was created in the 1940s for the movie industry and standardized by the American Standards Association as ASA C16.5-1942 (another of those examples where ASA does not mean Acoustical Society of America). This standard was superceded by IRE Standard 53 IRE 3.S2 in 1953, renamed IEEE Std 152-1953, and finally became ANSI C16.5 in 1954, which is now incorporated into IEC 60268-17. Take your pick—ASA, IRE, IEEE, ANSI or IEC—five organizations, same standard. Sure, different time frames, but the problem comes when an organization, manufacturer or writer references an old standard, leaving the reader or installer with the challenge of finding the current cross-reference.

Other interesting examples involve intermodulation distortion testing. What we know today as the SMPTE IM test has early roots. IM testing was first adopted in the United States as a practical procedure in the motion picture industry in 1939 by the Society of Motion Picture Engineers (SMPE, no "T" yet, reference 10) and made into a standard by the IRE in 1941 (reference 11). Originally numbered PH22.51 and titled "Intermodulation Tests for 16mm Variable-density Photographic Sound Prints," today, it is known as SMPTE RP 120: "Measurement of Intermodulation Distortion in Motion-Picture Audio Systems."

Finding this standard was comparatively straightforward; buying it was another matter. SMPTE does not yet have provisions to buy standards directly from its website, and it has yet to make a deal with a third party to offer them. All this is acceptable, even desirable, because it

Audio Engineering Society:

Standards and Recommended Practices, issued as of April 2000

AES2 AES recommended practice — Specification of loudspeaker components used in professional audio and sound reinforcement

AES3 AES recommended practice for digital audio engineering — Serial transmission format for two-channel linearly represented digital audio data

AES5 AES recommended practice for professional digital audio — Preferred sampling frequencies for applications employing pulse-code modulation

AES6 Method for measurement of weighted peak flutter of sound recording and reproducing equipment

AES7 AES standard for the preservation and restoration of audio recording — Method of measuring recorded fluxivity of magnetic sound records at medium wavelengths

AES10 AES recommended practice for digital audio engineering — Serial Multichannel Audio Digital Interface (MADI)

AES11 AES recommended practice for digital audio engineering — Synchronization of digital audio equipment in studio operations

AES14 AES standard for professional audio equipment — Application of connectors, part 1, XLR-type polarity and gender

AES15 AES recommended practice for sound reinforcement systems — Communications interface (PA-422)

AES17 AES standard method for digital audio engineering — Measurement of digital audio equipment

AES18 AES recommended practice for digital audio engineering — Format for the user data channel of the AES digital audio interface.

AES19 AES-ALMA standard test method for audio engineering — Measurement of the lowest resonance frequency of loudspeaker cones.

AES20 AES recommended practice for professional audio — Subjective evaluation of loudspeakers

AES22 AES recommended practice for audio preservation and restoration — Storage and handling — Storage of polyester-base magnetic tape

AES24-1 AES standard for sound system control — Application protocol for controlling and monitoring audio devices via digital data networks — Part 1: Principles, formats, and basic procedures

AES24-2 (proposed draft) AES standard for sound system control —

Application protocol for controlling and monitoring audio devices via digital data networks — Part 2: Data types, constants, and class structure
AES26 AES recommended practice for professional audio — Conservation of the polarity of audio signals
AES27 AES recommended practice for forensic purposes — Managing recorded audio materials intended for examination
AES28 AES standard for audio preservation and restoration — Method for estimating life expectancy of compact discs (CD-ROM), based on effects of temperature and relative humidity
AES31 AES standard for network and file transfer of audio — Audio-file transfer and exchange — Part 3: Simple project interchange
AES33 AES standard — For audio interconnections — Database of multiple-program connection configurations
AES43 AES standard for forensic purposes — Criteria for the authentication of analog audio tape recordings Information Documents
AES-1id AES information document — Plane wave tubes: design and practice
AES-2id AES information document for digital audio engineering — Guidelines for the use of the AES3 interface
AES-3id AES information document for digital audio engineering — Transmission of **AES3** formatted data by unbalanced coaxial cable
AES-5id AES information document for room acoustics and sound reinforcement systems — Loudspeaker modeling and measurement — frequency and angular resolution for measuring, presenting and predicting loudspeaker polar data
AES-6id AES information document for digital audio personal computer audio quality measurements
AES-10id AES information document for digital audio engineering — Engineering guidelines for the multichannel-audio digital interface (MADI)
Project Reports:
AES-R1 AES project report for professional audio — Specifications for audio on high-capacity media
AES-R2 AES project report for articles on professional audio and for equipment specifications — Notations for expressing levels
Cost of complete set, with no supporting documents, is $955.13 (March 2000)

keeps prices at a minimum, but the organization is understaffed, and it took two phone calls, two e-mails and three weeks to obtain (by e-mail) a two-page document. It did cost only $10, which, as you will see, is quite a bargain.

Another form of the IM test, popularly called the IM (CCIF) test, has traveled a torturous path only to get lost at the end. This is an alternate test for non-harmonic nonlinearities, using two equal-amplitude, closely spaced, high-frequency tones, and measuring their beat frequencies. Use of beat frequencies for distortion detection dates back to work first documented in Germany in 1929 (reference 12), but it was not considered a standard until 1937 when the CCIF recommended the test (reference 13). This test is often mistakenly referred to as the CCIR method (as opposed to the CCIF method), a mistake compounded by the many correct audio references to the CCIR 468 weighting filter.

If you think that is confusing, try following this historical path. The CCIF (*Comité Consultatif International des Téléphonique* or International Telephone Consultative Committee) merged with the CCIT (*Comité Consultatif International des Télégraphique* or International Telegraph Consultative Committee) becoming the CCITT (*Comité Consultatif International des Téléphonique et Télégraphique* or International Telegraph and Telephone Consultative Committee). In 1992, the CCITT, together with the CCIR (*Comité Consultatif International des Radio Communications* or International Radio Consultative Committee) morphed into the ITU (International Telecommunications Union). The ITU is divided into three sectors—radio communications (ITU-R), telecommunications development (ITU-D) and telecommunications standards (ITU-T). Since the CCIF became the ITU-R, the correct terminology today is the IMD (ITU-R) test. Did you follow all of that? If so, great, but the curious part is that there is no ITU-R standard for testing intermodulation distortion, at least not that I could find even after weeks of searches and inquiries. Nothing. No standard. No test. No recommendation. There is an ITU-T standard [O.42] on measuring nonlinear distortion using 4-tones, but it is not the one people generally mean. The final answer comes only after a long journey leading through the German DIN standards and eventually ending up back to that good old catchall IEC 60268 for the closest standard, but it fails to spell out the specifics of the CCIF method.

Prolific in nature

Simply put, standards beget standards. By the time you finish one standard you have acquired an entire genealogy of standards. The IEC inserts this alarming phrase in the beginning of every document issued, "The following normative documents [read standards] contain provisions, which, through reference in this text, constitute provisions of this part of the IEC standard." In other words, you must have all of these other referenced documents in order to know exactly what this document states. When you get these, each has this same magical phrase, so you now have to get your hands on those documents. Soon, if you pursue with diligence, one becomes four becomes 10 becomes 20.

For example, as mentioned earlier, IEC 60268 consists of 18 separate parts ("International Electrotechnical Commission: IEC 60268 Sound System Equipment," page 59). Therefore, you begin with 18 documents. These 18 documents reference 24 additional documents. Now, you have 42 documents, except that one of these (IEC 60068) consists of 114 parts, so the real total is 156 documents. That is not the end of it; all of the referenced 24 documents need checking to see how many more they reference and so on to a ridiculous degree.

The expense

Diligence costs you. Staying with our example above, consider that in March 2000, a complete set of IEC 60268, consisting of its 18 parts, cost $1,059.33, including shipping. The date is necessary because they are priced in Swiss Francs and subject to exchange rate fluctuations. It does not end there; if you need the supporting documents, the costs skyrocket. Just IEC's portion of the additional 24 supporting documents (referenced by the 18 parts of IEC 60268) adds $2,621.50 plus another $2,893 for one referenced document (IEC 60068, the one with 114 parts). Oh, and do not forget to add 7% for shipping, bringing the total for just the supporting docs to $5,900.52. A complete IEC 60268 package with supporting documents sets you back $6,959.85, delivered. You will still need six standards from ISO and ITU (with their supporting documents), whose costs have not been included.

Maybe it is because these are international documents; maybe that makes them more expensive. Compare them with buying AES standards. A complete set of AES standards, consisting of 29 documents (see "Audio Engineering Society: Standards and Recommended Practices, issued as of April 2000," pages 60-61), costs $955.13 (reference 14). No, the AES is not better, and yes, selling standards is a very-much-for-profit industry. As a counter example, compare to obtaining complete (including diagrams) U.S. patents directly off the U.S. Patent and Trademark Office website, which is free and a pretty good price.

IEC 60268: Not the answer

IEC 60268 is aimed primarily at analog-based equipment used in the reproduction of sound, either live or recorded. It does not cover audio recorders of any technology (magnetic, optical, vinyl, wire or any digital media). It does not cover radio, television, video, movie sound or broadcast in any form. It does not cover automotive sound or computer game sound. These all have separate standards.

Historically IEC has written separate multi-part standards for different market segments and for different aspects of the equipment used. For example, it issued IEC 60268 for "Sound System Equipment," IEC 60581 for "High-Fidelity Equipment," IEC 60574 for "Audio-Visual, Video and Television," IEC 61305 for "Household High-Fidelity Equipment," and IEC 60914 for "Conference Systems." It makes distinction among standards covering "characteristics," "measurement methods," "performance requirements" and "specifying." All these efforts have created a lot of conflicting paper, and it smacks more of bureaucratic inbreeding and satisfying special interests rather than truly contributing documents of lasting value.

IEC 60268 is an excellent example of good intentions gone bad. Although it may be a theoretical success, it is a practical failure. To begin with, reading IEC 60268 finds, instead of specifics, that it is peppered with the magic phrase

Websites for audio standards (excluding safety and EMI agencies)

AES (Audio Engineering Society) www.aes.org
ANSI (American National Standards Institute) www.ansi.org
ASA (Acoustical Society of America) www.asa.aip.org
BSI (British Standards Institution) www.bsi.org.uk
CCIR (International Radio Consultative Committee) See ITU
DIN (*Deutsches Institut für Normung*, the German Institute for Standardization) www.din.de This is currently a German language site, but bits and pieces are in English, with more to come. Until then, you can get around if you do not panic.
EBU (European Broadcasting Union) www.ebu.ch
EIA (Electronic Industries Alliance) www.eia.org
IEC (International Electrotechnical Commission) www.iec.ch
IEEE (Institute of Electrical and Electronics Engineers) standards.ieee.org/
ISO (International Organization for Standardization) www.iso.ch
ITU (International Telecommunication Union) CCIR is now ITU-R (International Telecommunication Union — Radio communication Sector), but the standards body is the ITU-T (International Telecommunication Union — Standardization Group) www.itu.ch
JSA (Japanese Standards Association) www.jsa.or.jp/eng/index.htm English language site.
NAB (National Association of Broadcasters) www.nab.org
RIAA (Recording Industry Association of America) www.riaa.com
SAE (Society of Automotive Engineers) www.sae.org
SMPTE (Society of Motion Picture and Theater Engineers) www.smpte.org

"rated value." The IEC definition of "rated value" is "The value stated by the manufacturer." This means it can be any value. The usefulness of this standard just went out the window. It is not a standard; it is a methodology and a compromise. Compromises are death to standards. The only thing standardized is style, not substance.

Begun in the early 1960s, this standard will never be finished. It attempts to cover all aspects of specifying and measuring every type of sound equipment for professional and consumer use, which is ambitious indeed. See Weeks (reference 2) for an excellent summary. Approaching 40 years old, this standard has not kept up with innovation. It has been revised and amended many times, but it still fails to be current. Technology moves much faster than standards committees.

Two goals were initially set. The first was to create international compatibility among pro audio equipment; the second was to make objective comparison of specifications possible. Neither was completely successful. The intent was to make professional audio units work together by standardizing connectors and cables and methods of interconnection. On one hand, this has been quite successful. Certainly, audio units from all different countries do connect using RCA pin-type connectors, ¼ inch TRS (tip-ring-sleeve) connectors, XLR-style circular connectors or any number of terminal block variations. On the other hand, look at what a failure it is because all these different methods of interconnect exist.

Why did the standard fail to specify one type of connector? The answer lies in the lack of specifics in this standard. On its way to becoming an international standard, it was compromised into uselessness. One country, company or industry wanted this connector, and another country, company or industry wanted another connector, so the great ambassadors of compromise put them all in.

Nevertheless, to be fair, if you use any of the connectors, they are standardized. Assuring that a ¼ inch connector made in Korea, wired onto a cable from China, used in a recording studio in New York to patch a unit made in Denmark into one made in Japan, it actually fits. That is a good thing.

What is not good, however, is that most professional audio units are wastefully fitted with three or four different connector types. A manufacturer has no way of knowing whether the customer requires XLR, RCA, ¼ inch or terminal blocks. If terminal blocks, do they prefer the American-type or the European-type. Making separate models and stocking three, four or five versions of the same product plus all the different voltage variations is not economically possible, so manufacturers must put them all on, which guarantees that 75% of the supplied connectors will remain unused for the life of the product. Millions of dollars are wasted each year on jacks that are never used.

In the second area covered by IEC 60268 regarding the ability to make objective comparisons, it fails professional audio by not giving specifics or by giving specifics applicable to consumer audio products. Further, IEC 60268 does not reflect the common practices of the professional audio industry; instead, it confesses to its consumer roots. For instance, it suggests a rated output of 0.5 V, instead of the +4 dBu (1.23 V) that professional audio uses, and a maximum output of 2 V, when professional audio maximum output is usually +20 dBu (7.75 V) or +26 dBu (15.5 V). Also, the reference for a S/N measurement is maximum out (which, of course, gives you dynamic range), not +4 dBu as is the industry working standard. Further on, it specifies a test source impedance of 200 Ω when measuring mic preamps, but our industry uses 150 Ω. Elsewhere, the reference voltage is suggested to be 1.0 V, except for telecommunications and broadcast, where it is to be 0.775 V, which is the only time telecommunications and broadcast are mentioned in this confused document.

Members of the AES are working to correct some of the problems found with IEC 60268. For example, AES14 clarifies ambiguous items in IEC 60268-12. Another AES committee is working to create an AES standard to replace IEC 60268-4, which allows such wide variations in test methods that it is effectively impossible to compare mics using this standard.

A website for audio standards

Little can be done to fix or change any of this. The number of organizations making audio standards is not going to be reduced. The redundancies and conflicts between them are not going to get better. The standards process is not going to be simplified. There is, however, one thing that can be done that would help audio design engineers all other the world, and that is to create an audio standards website where all audio standards are referenced with full search capabilities accessible by all. Such a website would allow people to look up any audio specification and see if there are standards associated with it. If so, then a hyperlink would take you to the Internet site offering that standard for sale.

The creation and maintenance of website for audio standards, because it best fits its charter, should logically fall to the Audio Engineering Society. It is a daunting task, and once created, it would always be changing, but that is the point. A central location is necessary to keep track of the continuous revisions, additions, and cancellations. Ultimately, all industries using audio would benefit from a central site. S&VC

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14. A word of caution should you check this out. It appears there is a CD-ROM that will save you money, but the price shown is a yearly fee for a subscription service, and it arrives as two CD-ROMs requiring two CD players in your machine, which you must access simultaneously. There is no separate CD-ROM available.