Audiovisual Systems Performance Verification Guide

For use with ANSI/InfoComm 10:2013,
Audiovisual Systems Performance Verification

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Acknowledgments

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Introduction

This guide is a companion to the standard ANSI/INFOCOMM 10:2013, *Audiovisual Systems Performance Verification*. The Standard provides a framework and supporting processes to assess and report whether an audiovisual (AV) system performs according to the client's agreed-upon expectations.

To help you set up the appropriate framework for verification and reporting of your organization's AV system performance projects, the Standard provides you with 160 reference verification items that represent tests and measures typically needed to verify an AV system's performance.

This guide provides detailed information about each reference verification item included in the Standard. It is designed to be searchable by individual reference verification item number. The guide also provides suggested metrics for 16 verification items that *require* a measurement and 11 items *should* include a measurement in addition to pass/fail to validate performance. Included are examples of test sheets and other important documents.

> **Important: Project Documentation!**
>
> The Standard and this corresponding guide are usable only if the project has appropriate project documentation. You cannot verify against something that doesn't exist. If you are charged with verifying an AV system's performance, your first step should be to request the project documentation.
>
> Project documentation may be different for each project. Guidelines for determining the necessary documentation are included in ANSI/INFOCOMM 2M-2010, *Standard Guide for Audiovisual Design and Coordination Processes*.
>
> Additional standards are planned to help with the project documentation process. Watch www.infocomm.org/standards for information about a *Minimum Documentation* standard and a *Design Package Verification* standard, slated for development in 2015-2016.
>
> ANSI/INFOCOMM standards are free to members. Go to www.infocomm.org/standards.

A Few Notes About Verification Item Selection and Reporting

- Very few projects will use all 160 reference verification items. The Standard provides the process for deciding which items to include.

- The list of reference verification items provided in the Standard is not meant to be all inclusive; your organization may have in-house, specific verification items, and those items can be easily incorporated into the processes defined by the Standard.

- Reference verification items are divided into logical categories based on how an AV system functions (e.g., Audio System Performance [AP], Video System Performance

[VP], Control Performance [CON]). Each item is assigned a unique three-digit number that cannot be altered, to establish a common numbering language for the entire industry.

▪ The Standard defines which items you will report to the client/owner at various times throughout this process (referred to as phases). You may issue a report more than once at any one or all of these phases:

1. Pre-Integration

2. Systems Integration

3. Post-Integration

4. Closeout

▪ On pages 20-21, the Standard also defines the specific format to use for these reports. Examples are provided in this guide.

InfoComm's APEx Program

InfoComm International® offers an AV Provider of Excellence (APEx) marketing recognition program for integration companies and AV design consulting firms dedicated to providing quality service to customers and upholding industry excellence. Implementation of ANSI/INFOCOMM 10:2013 and ANSI/INFOCOMM 2M-2010 is an integral part of this program.

Errata

As technology develops, some of the metrics defined in this guide may change. It is expected that some aspects of work started here will be superseded by InfoComm standards and education products. All effort has been made to research the existing knowledge base to provide cohesive information and guidance. We look forward to industry feedback and a cycle of continual improvement. Please send your proposed corrections to errata@infocomm.org.

Verification Item Descriptions

This section contains detailed descriptions and guidance on systems performance verification items. They are listed first by category and then by item number as they appear in the Standard. The categories are:

- Audio System Performance
- Video System Performance
- Audio/Video System Performance
- Cable Management, Termination, and Labeling
- Control System Performance
- System and Record Documentation
- Electrical
- Information Technology
- Operations and Support
- Physical Environment
- Physical Installation
- Serviceability
- Wireless

Audio System Performance

Verification Items within this category verify the audio system's performance, stability, and conformance to requirements provided within project documentation. Project-specific verification items that address capture, transformation, or reproduction of program audio or voice; audio signal management; acoustic environment; and loudspeaker operations shall be listed in this section.

AP-100 Emergency Systems Muting

Verify that any required muting or operational change of the installed sound system(s) has been made in accordance with local requirements and/or design specifications in the event of a life safety or similar emergency.

Introduction

For all phases, first, identify requirements for muting assessed from project documentation, and then identify local regulatory codes.

The following test inputs are required:

- Pre-integration—Systems design completed.
- Systems integration—Systems construction completed, control system programming completed, simulated control input available, and simulated emergency signal path available (if required).
- Post-integration—Sound, control, and emergency systems commissioned.

Tests, Procedures, and Equipment

Pre-Integration Phase

No physical test is possible at this stage, but check to ensure that the control methodology and the necessary system inputs have been defined in the design.

Integration Phase

Simulate the operation of the emergency system interface (e.g., by shorting out/opening the control system input). Audio system(s) must mute or provide required operational change (e.g., to allow the emergency signal to pass, if on a shared system).

Post-Integration Phase

The emergency system should activate the operation of the identified emergency system interface to the AV system. Audio system(s) must mute or provide required operational change (e.g., to allow the emergency signal to pass, if on a shared system).

Notes on Reporting

This test should also account for systems whose operations or signal paths may be shared with an emergency system rather than simply treating the requirement as if the AV system is wholly independent.

AP-101 Loudspeaker Zoning

Verify that loudspeaker zones are wired as defined in the project documentation.

Introduction

The following test inputs are required:

- Different loudspeaker lines should be disconnected and relocated to different amplifier channels or amplifiers. Connections should be tested and complete.
- All loudspeakers should be checked to ensure they are in correct zones.

Tests, Procedures, and Equipment

Tests

Audio test signal or audio program material should pass through individual loudspeaker lines, as shown in figure 1.
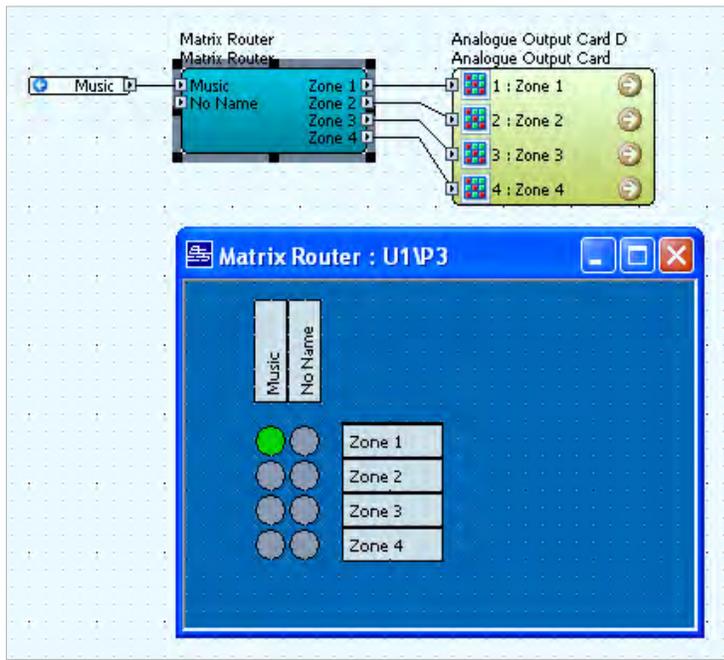
Figure 1 Matrix router

Procedure

Complete the following procedure:

- Set up a matrix router in the signal processor or a mixing console with multiple auxiliary outputs.
- Connect to various amplifiers powering up the loudspeaker lines.
- Pass audio test signal or program audio material through each line individually.
- Check if the audio is coming through one individual loudspeaker line or it is getting mixed with other lines.

Equipment

The equipment should include:

- Audio source
- Mixing console or open architecture digital signal processor (DSP)
- Amplifier
- Wired loudspeakers

Notes on Reporting

Note as pass/fail.

AP-102 Alignment of Multiple Audio Source Levels

Verify calibration of permanent audio system inputs such that the difference between any input signal level after the first common gain adjustment meets the requirements of the project documentation. This verification item should require a metric to be verified.

Introduction

Adjusting the audio levels between elements of an audio system is one of the most critical issues to the ultimate success of the system. There are usually adjustments throughout the audio chain and the installer needs to know where to make the adjustments to attain acceptable performance. These adjustments are called *setting the gain structure*, and there are two limits of tolerance the integrator takes into account to accomplish such a task:

1. No hiss or hum from the loudspeakers when there is no signal distributed

2. No overdriving distortion when the system is operating at its peak promised levels

While many other areas of the audio system operating parameters must be determined (e.g., ambient noise, headroom, dynamic range, and total harmonic distortion) for the system to operate optimally, the focus of this section is to ensure all individual elements in the signal chain are set to harmonious levels.

To complete the unity gain procedure and align multiple audio sources:

- Determine the common signal level within the system after the first common gain adjustment (typically, the pre-amplifier gain). On an analog or digital mixer, it is typically 0 dBu. On a DSP system, consider referencing the meter's "top of the green section" or determining some other level that gives adequate headroom like –15 dBFS.

- Check each source at the first gain adjustment to ensure that levels match.

- Introduce each source in turn at its nominal operating level to the input of the system.

- Adjust the mixer input until the desired common signal level is measured at the output of the channel strip. Use pre-fade listen metering, channel metering, or output metering with the channel fader and output faders set to 0 dB.

NOTE The documentation may specify a different procedure.

For DSP devices, this may correspond to the level indication on a post-gain meter. In most cases, professional mixers can yield another 20 dB of headroom without distortion. The additional headroom results in an improved signal-to-noise ratio.

In addition, audioconference mixers need sufficient input levels from the conferencing far side in order for the acoustic echo cancellation algorithm to work properly.

Setting the gain structure in a sound system is greatly simplified if the appropriate gain is applied at the mixer. Confirming that all source levels develop an identical level, such as 0 dBu, is the major part of audio calibration.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	
5. Manufacturer Documentation	
6. Other Best Practice Documentation	InfoComm International *AV Installation Handbook, Second Edition*, 5.23 – 5.34

Metric Selection

A typical system produces no more than a 1 dB variance in program source levels, when each program source is playing a calibrated media (i.e., setup test tone). However, this may vary between systems and should be specified in the system documentation.

Tests, Procedures, and Equipment

Verify levels via audio DSP or analog system level meters. Confirm that the levels are as specified in the system documentation.

Key goals of any audio system test should be to ensure there is no:

1. Hiss or hum from the loudspeakers when there is no signal distributed

2. Overdriving distortion when the system is running at nominal operating levels

In most cases, it is recommended that any automatic algorithms such as automatic gain control, noise cancellation, and audio gating be disabled during the system setup. If anomalies are found in the system during testing, disable the controls and test the system a second time.

Notes on Reporting

Any anomalies should be noted with specific reference to the active inputs and outputs in the system at the time of the testing. Specific levels should be noted at each adjustment point.

AP-103 Audio Buzz and Rattles

Verify that no audible noise caused by improper installation of any equipment provided in completed system(s) is present.

Introduction

Verify that no audible noise caused by improper installation of any equipment provided in completed system(s) is evident. Perform the buzz and rattles test, monitoring for both direct, or indirect, unintended noise generated as a result of the AV system operating within its designed parameters in the room environment. Noise that may be present as a result of non-AV system related sources (for example, air handler rattles due to excessive volume of air through it) is not in scope with this verification.

Tests, Procedures, and Equipment

Rattle Noise

Using a continuous sweep signal as an input to the sound system(s) operating at the level of 3 dB below the onset of distortion, monitor for any undesired acoustically induced noise (i.e., low frequency speaker output causing a loosely fitting grill to vibrate causing an audible harmonic distortion).

Buzz Noise

With all AV equipment on but with no content playback, verify to ensure no condition is causing noise within the audio system (i.e., an unbalanced input picks up, and amplifies a stray RFI/EMI signal that produces audible buzz). Again, the audio level setting should be at level 3 dB below the onset of distortion.

Each speaker should be verified individually.

Notes on Reporting

Note as pass/fail. Note the items for rectification.

AP-104 Audio Routes

Verify that all audio routes are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and routing as defined in the project documentation.

Introduction

This item covers testing of all audio paths to make sure they are passing audio from one point to the next. It verifies that labeling is correct, and that there are no transposed wires from one location to another.

Tests, Procedures, and Equipment

Provide a test signal at each input location and verify that the signal is present at the output of the associated wire. A spreadsheet noting each cable with a respective cable label should be used to track that each cable is tested.

For balanced connections, a common XLR cable test device can be used with various adapters to verify that the polarity of the cable is correct. An example unit would be the Whirlwind MCT-7 for a basic cable test unit or the Galaxy Audio Cricket for a kit that has a send and receive unit. These and similar units have LEDs to show that there is continuity between all terminated pins.

Notes on Reporting

Provide a spreadsheet with each cable identified and showing if it has passed the test.

AP-105 Reverberation Time

Verify reverberation time meets the requirement defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

Reverberation time is defined as the time in which the sound pressure level in a room or enclosure of a given frequency or frequency band decays by 60 dB. The AV design team must set the parameters of the reverberation time to suit the application. In smaller rooms, the discovery and management of room modes may be a higher priority than reverberation time. In larger spaces, reverberation may play a much larger role. Because the actual measurements include many factors, measurements are best left to an acoustician.

The importance of reverberation time in room design is critical because it can be very costly to correct. As the reverberation time increases, the more a sound appears to echo. Larger spaces will naturally have longer reverberation times. Rooms with hard surfaces such as polished concrete, floor tiles, glass, and stone will have longer reverberation times than those with carpet and ceiling tiles. Acoustic absorption materials (e.g., acoustic paneling and ceiling tiles) can be used to reduce reverberation times but affect the aesthetics of the room, so there is a significant need to discuss material with the interior designers and owner.

In retrofit/refurbishment environments, if times are outside the recommended guidelines, the reverberation time must be measured and corrective action should be taken.

Due to the cost of mitigation, corrective action may mean considering an alternative room in some instances.

The optimum reverberation time is dependent on the specific physical environment and AV application.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	AS/NZS 2107:2000, *Acoustics—Recommended design sound levels and reverberation times for building interiors* AS/NZS 2460, *Acoustics—Measurement of the reverberation time in rooms* BS EN ISO 3382-2:2008*, Acoustics—Measurement of room acoustic parameters—Part 2: Reverberation time in ordinary rooms*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	

Metric Selection

Metric selection should include the type of room based on the recommendations from the international acoustics standards and manufacturers' documentation. Particular attention should be paid to rooms with videoconferencing.

AS/NZS 2107 provides information about recommended reverberation times. These recommended times refer to the medium frequencies (e.g., 500 Hz or 1000 Hz) for a fully fitted-out and completed building. It is generally acceptable in large volume spaces to have some increase in reverberation time toward the low frequencies. For large volume spaces, the recommended reverberation time assumes that the space is at two-thirds occupancy. For small volume spaces, it may be more suitable to make reverberation times independent of frequency.

Tests, Procedures, and Equipment

Use an impulse noise test to determine the reverberation time within a room.

The impulse noise test is routinely performed using an impulse noise source such as a balloon and a reverberation time meter. The balloon is popped and the meter provides an instantaneous result. The impulse must be sufficient to produce an impulse of 40 dB above the background noise level in the room.

The procedure for measurement of reverberation time shall comply with BS EN ISO 3382-2:2008 or AS/NZS 2460, depending on location.

Measurement Positions in Large Spaces

In a large auditorium, reverberation times vary from seat to seat. Therefore, it is important to include an adequate number of source and receiver positions to characterize the entire space.

Normally, a minimum of three on-stage source positions are used. In spaces with large stages or orchestra pits, more positions are needed. In small lecture theatres where the normal source has only one location in the room, a single source position is acceptable.

A minimum of between six and 10 representative microphone positions are used depending on the size of the space. Where spaces are broken into separate areas, such as balconies and under-balcony areas, more receiver locations will be necessary. Microphones should be placed at normal listening height of 1.2 m (4 ft).

Notes on Reporting

It is recommended that the reporting for this item include the following:

- Volume of the room in cubic meters or equivalent cubic feet, depending on location

- Record reverberation time by frequency in milliseconds (ms)

- For auditoriums, note the number of seats in the room

- Note the position of variable items such as blinds and curtains

- Type and position of impulse source used

For larger auditoriums and performance venues, it is recommended to refer to the referenced standards for the full list of procedures and reporting items.

AP-106 DSP Programming

Verify that all DSP-based products have been programmed as defined in the project documentation.

Introduction

The main concern in this item is to ensure the digital signal processor (DSP) programming has been performed and the audio system is ready to be tested. As audio processing equipment progressed during the last decade, what was once controlled and adjusted by analog potentiometers moved to solid-state DSPs.

The newer DSP devices now provide functions such as signal routing and matrixing, level adjustments, microphone mixing, acoustic echo cancellation, and a lengthy list of signal processing features. In some cases, programming can be as simple as assuring the default setting is selected, while other systems may take days and weeks of effort and adjustment.

Quality programming of audio processing may be considered art rather than science. And, there may be many correct ways to achieve satisfactory results in the same space. Success in audio DSP programming depends on a solid background in the fundamentals of audio. Understanding the adjustment mechanisms within the DSP is not enough to provide a well-tuned system.

DSP systems offer many options, settings, and features. Oftentimes, a seemingly simple adjustment can affect multiple other areas in the audio system, so a solid understanding of the overall goal of the system is important to programming success. These goals may be found in the system documentation. In other cases, they must be determined by the programmer.

Note that the DSP programming interface is actually an application that manipulates the system and does not involve manual DSP coding, which is built in during product development.

It is important to determine early in the project who will be responsible for the design and programming of the DSP application. In some projects, the design consultant provides the DSP programming. At other times, an independent programming specialist may assist with the project. In the majority of projects, the integrator performs the programming over the course of the project. In almost every case, a preliminary programming design will need to be adjusted to match the actual conditions in the project environment.

Programming resources may include line drawings for signal routing and reference to specific metrics for all audio performance parameters. Static and dynamic signal routing must also be addressed. In many cases, a prudent course is to use the default product settings and make adjustments. Most manufacturers now offer settings whereby major components adjustments have already been considered and activated to match typical configurations.

Typical checkpoints for DSP programming (from *AV 9000: Defining Quality in Engineered Audio Visual Systems*) should include:

- Are all inputs and outputs accurately labeled and accounted for?

- Does the signal flow make sense? Is each source proceeding to each destination?

- Is each "block" (e.g., EQ, delay) in the chain desired/necessary?

- Is each "block" doing something (i.e., is not bypassed)?

- Are all inputs arriving at the same level (i.e., 0 dBu)?

- Are all outputs leaving at the same level or the level specified by their destination (i.e., some codecs require –10 dBu)?

- If using multiple units, are all buses labeled and properly designated?

- If you are setting threshold, are you taking into account room noise level (i.e., if the threshold is set too high, the microphones won't turn on. If it's too low, will room noise gate the microphones)?

- Are all local microphones in the room using echo cancelling actually using the echo canceller reference?

- Is everything except local microphones (including microphones that are *not* sent to the far end) included in echo canceller reference?

- Does every crosspoint (output and input) make sense?

- Is every input not directed to itself (i.e., input 1 is set 27 dB higher than input 2 for no apparent reason)?

- Do the presets fulfill all their requirements?

- Does the number of open microphones (NOM) bus have microphones only? Are program sources not on the NOM bus(es)?

- While setting the delay times for local reinforcement, did you account for the Haas effect (add another 20 ms) for better localization?

Tests, Procedures, and Equipment

Testing and performance of audio systems is addressed in other areas of the verification list. Equipment necessary to perform this check varies by manufacturer but typically requires a PC

or handheld computing device connected to the audio DSP. Many products offer built in displays that can be used to verify the programming has been completed. Additional adjustments will likely be necessary to achieve optimal performance, but it will be important to verify that the DSP is at least at a starting point prior to testing.

Notes on Reporting

Ensure that any changes made to a DSP system are saved and noted.

Original programming and build versions should also be saved and archived outside of the actual DSP product as a safeguard in case of product failure.

The contractor should also determine where these files should be saved and stored by reference to project documentation of guidance from the end client. In some cases, the best place would be near the equipment rack so that it can be readily available to technicians when servicing the system.

AP-107 Loudspeaker Physical Alignment

Verify that loudspeakers are placed and aimed as defined in the project documentation.

Introduction

This item covers the procedures to confirm that the loudspeakers are placed and aimed at the rear of the seating area to cover a typical audience area.

These items should be checked and verified before testing:

- Loudspeakers should be connected as per the project documentation.
- Loudspeaker mounting should have flexibility to change the mountings/direction of loudspeakers to achieve desired results.

Tests, Procedures, and Equipment

Check the project documentation for the loudspeaker physical mounting information. Check that the loudspeakers are mounted in the location specified, at the correct height, and with the proper vertical and horizontal aiming. Project documentation should show the physical placement and aiming information of the loudspeakers in the project. In the case of program loudspeakers, whether a single speaker or cluster, the documentation shall list height, horizontal, and vertical angle. For line arrays, the physical location and aiming of the top box in the array shall be followed by the inter-box angle of the other loudspeakers in the array.

Once that it's been confirmed that the loudspeakers are aimed per project documentation, proceed to AP 114 Audio Coverage in Listener Areas to verify coverage uniformity.

Notes on Reporting

A pass/fail reporting is all that is required by the Standard.

AP-108 Loudspeaker Polarity

Verify that all loudspeakers have correct polarity as defined in the project documentation.

Introduction

The complete audio chain, from input (e.g., microphone, audio source) to output (e.g., loudspeaker) should be connected. Loudspeaker polarity, which refers to the physical terminations at the loudspeaker (not the phase of sound waves), can be accidentally reversed at any point in the signal chain. Therefore, it is very important to do a polarity test after the complete audio chain is connected.

Tests, Procedures, and Equipment

Tests

Perform a loudspeaker polarity check.

Procedures

A standard polarity tester set contains two devices: a generator and a detector. An impulse tone is injected as an input to the audio chain, and the detector is placed in front of the loudspeaker. Indicators on the detector unit show whether the polarity is normal or inverted. Each loudspeaker in a multi-way configuration should be tested separately.

Equipment

The equipment should include a complete audio chain, a polarity generator, and a polarity detector.

Notes on Reporting

A pass/fail reporting is all that is required by the Standard.

AP-109 Loudspeaker Time Alignment

Verify that loudspeaker time alignment performs as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

This item covers the procedures and measurements to achieve correct time alignment between various loudspeakers that may be distributed across the room for ideal audio coverage over the listening area. A correctly aligned system can create a sense of audio localization to the main area of action such as a stage in the auditorium. In a system that is not aligned, speech intelligibility may drop drastically, and the audience may hear unwanted double sounds from the surroundings, which could build up to become an echo.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	Physical loudspeaker placement in the venue and audio level match between different loudspeaker rings
3. InfoComm Standards	
4. Other Standards	
5. Manufacturer Documentation	
6. Other Best Practice Documentation	

Metric Selection

Best-case metrics for correct time alignment is 20 ms behind the main sound source. Maximum accepted range of time for alignment is 25 to 35 ms.

Tests, Procedures, and Equipment

The following tests and their associated procedures are required to complete this verification Item:

- Audio test source—A pink noise generator or sine wave sweep generator

- Sound analyzer device—Many devices and software packages are available (e.g., SIA Smaart, EASE RA, TEF, various tablet apps, NTi Minilyzer, NTi XL2, Bruel & Kjaer devices). A measurement device shall display a 20 Hz-to-20 kHz spectrum of audio in dB SPL at a minimum of 1/12 octave bands. A dual channel system capable of comparing a test stimulus audio source to a reference microphone input is preferred.

- Pre-amplifier/input device—Most real time analyzers (RTAs) today are software based. A quality microphone pre-amplifier/input device is required to transfer the audio from the microphone to the computer or tablet device running the software (e.g., Sound Devices USBPre 2).

A suggested test procedure would be to:

1. Route the signal to an input of the system using a pink noise generator and matching the input sensitivity to achieve a unity gain signal.

2. Route the signal to the test software or RTA device (if it is a two-channel device that can show the difference between the test signal and the signal after routing through the system).

Figure 2 Signal flow for testing time alignment

3. Connect an output of the system (line level or microphone level) to the test software or RTA device. If an output such as a record output is not available, use the final output device before the amplifier.

4. Unmute single loudspeaker stack and measure the distance in delay locator or impulse response window of the software. An example is shown below.
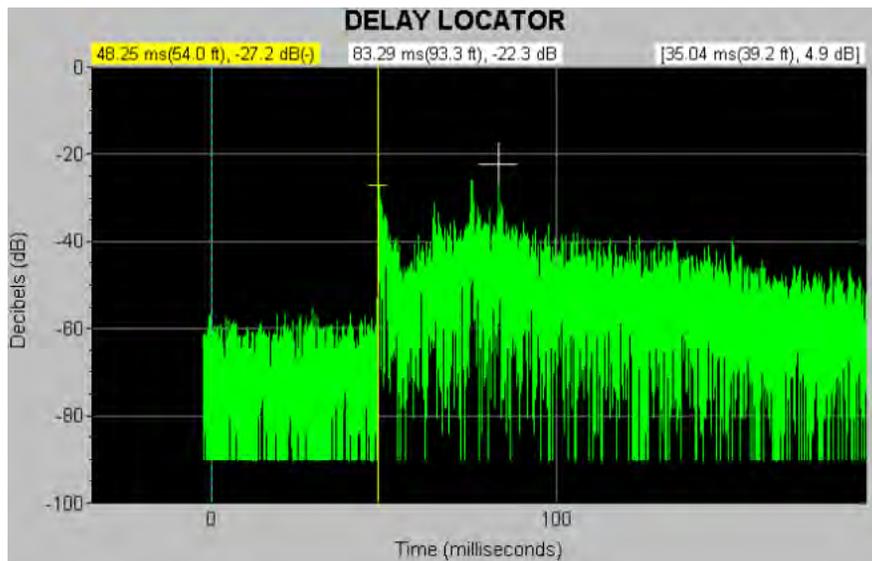
Figure 3 Showing the first arrival of sound at 48.25 ms from the primary stack at the microphone position
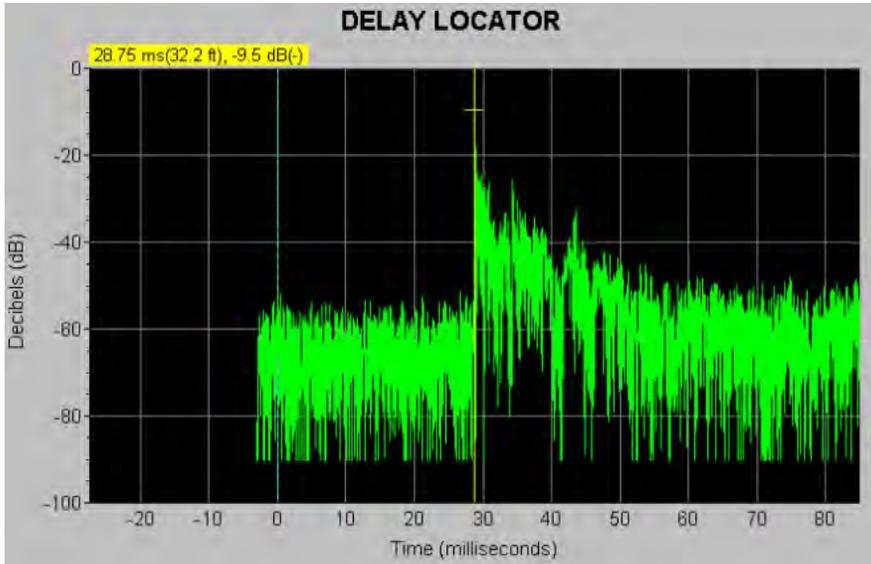
Figure 4 Showing the first arrival of sound at 28.75 ms from the secondary stack at the microphone position

5. Repeat the same procedure for the second loudspeaker stack and mute the primary loudspeaker stack. The difference between two time arrivals is 19.47 ms and meets the time delay required for the secondary stack for absolute time alignment.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

AP-110 Phantom Power

Verify that phantom power is provided at the correct voltage and correct locations as defined in the project documentation.

Introduction

Phantom power is the term for voltages applied on an audio cable. Phantom power is used to supply the voltages necessary to operate condenser microphones or small peripheral devices. The voltages range from 12 V to 48 V DC and are carried equally over the conductors of a balanced audio line. Phantom power can cause damage to other electronics, including ribbon microphones. The correct application should be specified.

Applicable standards are:

- Standard IEC 61938 P12
- Standard IEC 61938 P24
- Standard IEC 61938 P48

Tests, Procedures, and Equipment

For an XLR3 connector, using a multimeter set for DC voltage, measure between pins 1 and 2 and pins 1 and 3. The voltages should have the same readings.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

AP-111 Loudspeaker Transformer Tap Setting

Verify the loudspeaker transformer tap setting in constant voltage systems is as defined in the project documentation.

Introduction

Constant voltage systems leverage Ohm's law to send signals over long distances by reducing the current and increasing the voltage output of the amplifier. At each connected loudspeaker, it is necessary for a transformer to lower the voltage. This is done by setting a tap. The transformer taps allow specified amounts of power to reach the loudspeaker. A loudspeaker's tap setting is determined by the amount of power needed and the amount of amplifier power available. Incorrectly selecting a tap can result in overdriven amplifiers or low acoustical output.

Tests, Procedures, and Equipment

Verify the loudspeaker system by calculating the predicted impedance and then using an impedance meter to check the line.

This will verify two things:

1. All loudspeakers are connected.

2. All loudspeakers are tapped correctly.

If your impedance checks out, you don't have to manually verify the tap and wiring on each loudspeaker.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

AP-112 Acoustical Ambient Noise

Verify that the background acoustic noise levels within audiovisual spaces are within the required limits as detailed in the project documentation. This test is specifically related to ambient noise levels and not audio system quiescent noise, which is tested separately. This verification item shall require a metric to be verified.

Introduction

Acoustical ambient noise can be a large factor in the effectiveness of an AV system. Excessive ambient noise levels result in less effective communication due to listener fatigue. Ambient noise can come from outside the room and could include sounds from adjacent rooms, foot traffic from spaces above, structure-borne vibrations and traffic on the street. Background noise also can come from sources within the room, particularly from the HVAC system, as well as from audiovisual equipment such as projectors, displays, and power amplifiers.

This test should be performed under full normal working conditions for the building and during normal working hours. It is very important to take measurements in the most realistic conditions possible.

An acoustician, AV consultant, or designer specifies the maximum acoustical ambient noise limits to the architect, other consultants on the project, and the owner. An AV professional prepares a report that informs the other parties of certain decisions about construction techniques, devices, and implementation of various aspects of the building services.

The dB SPL A-wtd measurements from AP-112 Acoustical Ambient Noise or a noise criterion (NC)/room criteria (RC) rating will be used as a reference to help determine compliance with the AP-116 Audio Level Exceeds Background Noise Level test.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	ANSI S1.13-2005, *Acoustics series; Measurement of Sound Pressure Levels in Air* ANSI S12.60-2002, *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools* ANSI/ASA S12.2-2008, *Criteria for Evaluating Room Noise* AS/NZS 2107, *Acoustics—recommended design sound levels and reverberation times for building interiors* IEC 60804/BS EN 60804/AS 1259.2, *Electroacoustics—Sound level meters—Specifications*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	ASHRAE *Fundamentals Handbook*, chapter Sound and Vibration

Metric Selection

An acoustician, audiovisual consultant, or designer specifies the maximum background noise limits to the architect, other consultants, on the project and the owner. When the project

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design goal for maximum acoustical ambient noise is not stated or known, the professional who performs the testing should consider corresponding standards.

The actual metric selection should include and compare the type and use of the room with the recommendations within the international acoustics standards and manufacturer documentation. Particular attention should be paid to rooms that will incorporate videoconferencing.

Tests, Procedures, and Equipment

The room to be tested should be set up as follows:

- HVAC is operating normally. All associated building plants in the vicinity are operating normally.

- Windows and doors are open or closed.

- Neighboring spaces in the building are occupied with normal activities in operation.

- Background noise level requirements are determined from project documentation.

- Sound system is switched off.

- In situations where traffic (or other) noise levels may vary widely over a 24-hour period, measurements to assess compliance should be taken at the relevant time according to the area of occupancy or activity in the building.

- Measurement of background noise can be undertaken using a sound pressure level (SPL) meter/spectrum analyzer to determine background noise levels dB A and/or NC and NR rating, as required. Measurements need to be made throughout the space.

- When using a sound pressure level meter, make sure the meter is set to *A-weighted* and *Slow* response.

- The measuring instrument should be used in accordance with AS 2659, *Guide to the Use of Sound Measuring Equipment*, and sound level meters should be in compliance with IEC 60804/BS EN 60804/AS 1259.2.

Notes on Reporting

Record the locations of each test position. Output could be in the form of a grid map with noise levels or a tabulated list of measurements against grid positions. Include a pass/fail statement and any indication of likely sources of noise that may need to be addressed. Units are in dB A-wtd.

When required to report a measurement as a specific noise criterion or noise rating, use the following example to correlate the dB SPL A-wtd measurements at each octave band center frequency.

Example: Estimating Noise Criterion (NC)

(Content courtesy of NTi Audio)

The curve rating can be obtained by plotting the octave band levels for a given noise spectrum. The noise spectrum is specified as having a curve rating the same as the lowest noise curve, which is not exceeded by the spectrum. The NC of a noise spectrum can be estimated at NC 45, as indicated in figure 5.

- 62.5 Hz: 48 dB
- 125 Hz: 46 dB
- 250 Hz: 42 dB
- 500 Hz: 37 dB
- 1000 Hz: 34 dB
- 2000 Hz: 36 dB
- 4000 Hz: 37 dB
- 8000 Hz: 40 dB
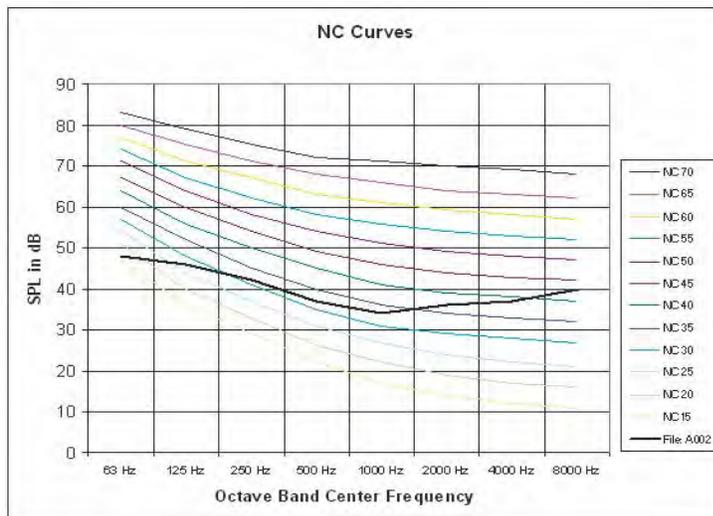
Figure 5 NC curves with sample result

Supplemental Information

The metric to be verified is region specific and the following is noted:

- Noise criterion (NC) is used in the United States. It was developed and identified in Acoustical Society of America (ASA) and American National Standards Institute (ANSI) specifications. It is used to rate ambient noise and interference from all sources, including HVAC sources.

- Noise rating (NR) is used in the United Kingdom and Europe. It was developed in an International Organization for Standardization (ISO) Standard to determine acceptable indoor spaces for hearing preservation, speech communication, and listener distraction.

- dB A-wtd level is used in Australia and New Zealand.

These definitions are coarse generalizations and do not hold true for all projects. In many instances, any of the above performance criteria can be used on a project including other

metric types such as room criteria (RC), preferred noise criterion (PNC), RC mark II, New NC, or STC.

Recommended Noise Criterion (NC)

Consider the noise criterion limits listed below for NC levels in different spaces:

Table 1 Recommended NC limits for a variety of spaces (Courtesy of NTi Audio)

Type of Room—Space Type	Recommended NC Level (NC Curve)
Apartments	25-35
Assembly Halls	25-30
Churches	30-35
Courtrooms	30-40
Factories	40-65
Private Residences	25-35
Restaurants	40-45
TV Broadcast Studios	15-25
Recording Studios	15-20
Concert and Recital Halls	15-20
Sport Coliseums	45-55
Sound Broadcasting	15-20
Movie Motion Picture Theaters	30-35
Libraries	35-40
Hotels/Motels	
- Individual Rooms or Suites	25-35
- Meeting or Banquet Rooms	25-35
- Halls, Corridors, Lobbies	35-40
Offices	
- Conference Rooms	25-30
- Open-Plan Areas	35-40
- Business Machines/Computers	40-45
Hospitals and Clinics	
- Private Rooms	25-30
- Operating Rooms	25-30
- Public Areas	35-40
Schools	
- Lecture and Classrooms	25-30
- Open-plan Classrooms	35-40

Further Reference

Also refer to AP-105 Reverberation Time in this guide for the sound pressure levels metrics per application, as defined in AS/NZS 2107.

Recommended Noise Rating (NR) Levels

For different space types, consider the NR levels indicated in table 2:

Table 2 Recommended NR levels for several spaces (Courtesy of NTi Audio)

Noise Rating Curve	Application
NR 25	Concert halls, broadcasting and recording studios, churches
NR 30	Private dwellings, hospitals, theatres, cinemas, conference rooms
NR 35	Libraries, museums, court rooms, schools, hospitals, operating theaters and wards, flats, hotels, offices
NR 40	Halls, corridors, cloakrooms, restaurants, night clubs, offices, shops
NR 45	Department stores, supermarkets, canteens, general offices
NR 50	Typing pools, offices with business machines

NR 60	Light engineering works
NR 70	Foundries, heavy engineering works

Recommended A-Weighted Levels

For different space types, consider the recommended dB SPL A-weighted levels in table 3:

Table 3 Recommended dB SPL A-wtd levels (Courtesy of NTi Audio)

Type of Room—Space Type	Equivalent Sound Level (dBA)
Assembly Halls	35-40
Churches	40-45
Courtrooms	40-50
Factories	50-75
Private Residences	35-45
Restaurants	50-55
Libraries	40-50
Hotels/Motels	
- Individual Rooms or Suites	35-45
- Meeting or Banquet Rooms	35-45
- Halls, Corridors, Lobbies	50-55
Offices	
- Conference Rooms	35-40
- Open-Plan Areas	45-50
- Business Machines/Computers	50-55
Hospitals and Clinics	
- Private Rooms	35-40
- Operating Rooms	35-40
- Public Areas	45-50
Schools	
- Lecture and Classrooms	35-40
- Open-Plan Classrooms	45-50

AP-113 Assistive Listening Devices

Verify that all devices that are part of the assistive listening system have been tested as a complete end-to-end personal listening system. Verify that the assistive listening system complies with regulatory requirements and adheres to project documentation. This verification item should require a metric to be verified.

Introduction

Assistive listening devices are most commonly installed to satisfy regulatory requirements to suit a certain area or rooms for the hearing impaired, but no prescription is given for the type of system that is required to be deployed. In practice, three types of systems are used:

- Induction loop
- Frequency modulation (FM)
- Infrared (IR)

Each system requires different metrics for verification, with induction loop systems governed uniformly by international standards.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	*Americans with Disabilities Act (ADA)* *Building Code of Australia*
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	AS 1428.5-2010, *Design for access and mobility—Part 5 Communication for People who are Deaf or Hearing Impaired* AS 60118.4*, Hearing aids Part 4: Magnetic field strength in audio frequency induction loops for hearing aid purposes* BS EN 60118-4:2006*, Electroacoustics. Hearing aids. Induction loop systems for hearing aid purposes. Magnetic field strength* ICC/ANSI A117.1, *Accessible and Usable Buildings and Facilities* IEC 60118-4, *Electroacoustics—Hearing aids—Part 4: Induction loop systems for hearing aid purposes—Magnetic field strength Edition 2*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	BS 7594, *Code of practice for audio frequency induction loop systems (AFILS)*

Metric Selection

Metrics for an audio induction loop system should be based on a regional standard, such as IEC 60118.4, as follows:

- Magnetic field strength at the listening height must be 400 mA/m (RMS) +/– 3 dB.

- Variation of field strength across the listening plane must not change by more than +/– 3 dB.

- Frequency response of the system must be within +/– 3 dB of the level at 1 kHz from 100 Hz to 5 kHz.

- Background magnetic noise over the listening volume should be no worse than –47 dB(A). However, a background magnetic noise level no worse than –32 dB(A) is acceptable.

For IR- and FM-based systems, the following should apply:

- Refer to the manufacturer's requirements for signal strength in the various frequency bands of operation.

- In some countries, licensing is required for operation of FM systems (e.g., in the United Kingdom for systems operating between 175.100 and 177.150 MHz).

Tests, Procedures, and Equipment

A comprehensive test procedure for this item is detailed in AS 1428.5-2010. Some of the subjects and issues in the Standard are listed below. For complete details on testing, the Standard will need to be obtained.

Induction Loop Systems	**Modulated Radio Systems**	**Infrared Systems**
▪ Frequency response	▪ Frequency response	▪ Frequency response
▪ Distortion	▪ Distortion	▪ Distortion
▪ Compressor/AGC or equivalent	▪ Compressor/AGC or equivalent	▪ Compressor/AGC or equivalent
▪ Power source	▪ Power source	▪ Power source
▪ Min/max magnetic field strength	▪ Receiver and accessories	▪ Receiver and accessories
▪ Background magnetic field strength	▪ Signal-to-noise ratio	▪ Signal-to-noise ratio
▪ Functional testing	▪ Signage	▪ Signage
▪ Loop receiver		

Notes on Reporting

Note as pass/fail. Prepare a full test report where required by the project documentation.

AP-114 Audio Coverage in Listener Areas

Verify that coverage of the audio systems in listener areas meets the performance requirements as defined in the project documentation. ANSI/INFOCOMM 1M-2009, *Audio Coverage Uniformity in Enclosed Listener Areas*, should be used. Perform separate tests for all independent systems within the project, including but not limited to program sound, speech reinforcement and show relay. This verification item should require a metric to be verified.

Introduction

This item is to verify that the coverage of audio systems in the listener areas complies with the ANSI/INFOCOMM 1M-2009 standard. The complete audio system should be commissioned, considering and complying with other relevant verification items listed in this guide.

Tests, Procedures, and Equipment

Follow the test procedures as listed in ANSI/INFOCOMM 1M-2009, depending on the type of application.

Notes on Reporting

Refer to the ANSI/INFOCOMM 1M-2009 standard. Follow the tests and procedures listed in the Standard.

AP-115 Audio Dynamics

Verify use of audio dynamics, including but not limited to noise compensation, automatic gain control, gating, feedback suppression, compression, limiting, delays, and levelers meets the requirements defined in the project documentation.

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Introduction

Many devices in an audio signal path control the dynamics or amplitude of the signal. Many of these hardware and DSP-based devices automatically affect the dynamics based on the settings that often are not adjusted once the system is commissioned and handed over to the owner. Improper settings at any stage can drastically affect overall system performance.

Suppose a DSP manufacturer has a crossover block in their inventory of processor blocks. In addition to the standard filter settings, crossover types, gain, and phase settings, the crossover block includes a threshold setting for a limiter. By default, the threshold is set to –20 dBu. If this particular setting is unknown to the person configuring the DSP, it could be very difficult to figure out why the amplifiers are getting lower than expected signal. Once the setting is discovered, a quick adjustment to the setting produces great results.

Compressors are another area where settings can easily improve or harm the audio. Compression should be set so that only the amount needed is used. Improper use of compression can restrict audio from sources and even make microphones more susceptible to feedback.

Many conferencing processors have automatic gain compensation. All dynamic processors are very dependent on proper gain structure for everything upstream of the processor. Automatic gain compensation works poorly if the input gain to the unit or block is not adjusted correctly. Automatic gain can be set to increase volumes that are initially too low, introducing background noise into the audio path. It also may reveal other issues like improper microphone placement or acoustic issues.

Tests, Procedures, and Equipment

After the gain structure has been set and adjustments for microphone placement completed as required in project documentation, check each dynamics block or piece of hardware. Identify proper input and output gain for each block. Specifically check for clipping at each input and output stage. For gating mixers (DSP or hardware), check that the threshold of the gate is set to allow for the prescribed use of the system, with no muting of desirable audio.

Properly setting limiters involves many factors. However, by running the systems at levels indicated in the project documentation, no clipping should be present at any stage. Increase system gain to the point where clipping begins at the output stage of the device to the amplifiers, or at the amplifiers. The limiter thresholds should be set slightly lower than this point to prevent the amplifiers and output stages of the processor or DSP from clipping.

Notes on Reporting

Final DSP files shall be delivered to the customer with proper dynamics settings. Note any major dynamics issues and changes to settings in the submittal report.

AP-116 Audio Level Exceeds Background Noise Level

Verify that the audio level provided by the installed audio system exceeds the background noise level as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

Whenever people listen to sound, the amplitude of the sound should exceed any noise that may distract the listener from detecting all of the nuances. If the background noise is too intense, it will mask what people want to hear.

The audio system designer should state how much the audio level should exceed the background noise level. This level is called the signal-to-noise (S/N) ratio.

After verifying AP-112 Acoustical Ambient Noise, the results should be compared to the sound system's audio level.

As an example, ANSI/ASA S12.60 indicates that maximum one-hour SPL levels, including those from building services, such as HVAC, should not exceed 35 dB SPL A-wtd for spaces not exceeding 566 m^3 (20,000 ft^3) in classrooms and other learning spaces.

If the maximum background noise level as indicated by the standard is 35 dB SPL A-wtd and the minimum S/N ratio is 25 dB, a minimum of 60 dB SPL A-wtd for amplified speech level may be achievable.

However, if the background noise (ambient noise) measurement is higher than expected, such as 55 dB SPL A-wtd, the S/N ratio requirement of 25 dB increases the audio level beyond the minimum of 60 dB SPL A-wtd to 80 dB SPL. The S/N ratio of 25 dB cannot be maintained, and verification would fail.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	ANSI S12.60-2002, *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	*InfoComm Installation Online: Elements of Setup and Verification*

Metric Selection

The audio system designer should state how much the audio level should exceed the background noise level. This determination may be based on the venue and the audio content.

When it is not known or stated as a project design goal how much the audio level should exceed the background noise level, the professional who performs the testing may use the following metrics to form a pass/fail judgment.

- 15 dB S/N is the recommended minimum for spaces where the background noise is 35 dB SPL A-wtd.

- 25 dB S/N is an InfoComm International best practice.

NOTE Generally, a good target for overall sound pressure level is 25 dB above the ambient noise level. Blindly setting a sound system for 25 dB above ambient noise where ambient noise is higher can produce a system that is excessively loud and intelligibility will drop (i.e., if the sound is too loud, people will experience fatigue and become distracted).

Tests, Procedures, and Equipment

Ensure that measurement locations are the same as the measurement locations used in the AP-112 Acoustical Ambient Noise, so the two measurements are aligned by location.

InfoComm's course *Elements of Setup and Verification Online* explains how to measure an AV system's sound pressure level.

Notes on Reporting

Record the locations of each test position. Output could be in the form of a grid map with noise levels or a tabulated list of measurements against grid positions. A pass/fail statement and any indication of type of failure (e.g., audio system performance or room acoustical ambient noise problem) should be created. The difference between the audio level and the background noise is a ratio and should be recorded in decibels.

AP-117 System Electronic Frequency Response

Verify that the electronic frequency response of the audio system is as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

This item covers the capability of an audio playback system to accurately reproduce the audio source device's frequency response in the electronic domain. This does not include the frequency response of the microphone or the acoustic measurement of frequency response of loudspeakers.

Project documentation shall define the measureable frequency response of the system. In the absence of defined target frequency response, a flat response from 20 Hz to 20 kHz shall be used.

Additional system elements affect final system frequency response and are referenced in other sections of this guide, such as system gain settings, crossover settings, compression, and limiting. For example, providing audio for separate frequency ranges in a three-way system can

greatly affect system frequency response. Setting gain levels of processors that feed amplifiers is important for optimal system performance. In this case, adjusting system gain would be the first requirement in testing the frequency response.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	
5. Manufacturer Documentation	RaneNote 145. 2000. *Audio Specifications.* Rational Acoustics. 2010. *Anatomy of a Measurement Rig: Probes, Preamps and Processors.*
6. Other Best Practice Documentation	

Metric Selection

Basic hearing frequency response has produced an industry standard of 20 Hz to 20 kHz for full-range audio equipment. In the absence of a design specification, use 20 Hz to 20 kHz.

A sample statement to use is, "The system under test shall produce a flat frequency response (+/– 0.5 dB) from 20 Hz to 20 kHz."

During testing, the design specification and the measured results should be recorded. The pass/fail status should also be documented.

Tests, Procedures, and Equipment

The following equipment is required to complete this verification item:

- Audio test source—A pink noise generator or sine wave sweep generator

- Sound analyzer device—Many devices and software packages are available (SIA Smaart, EASE RA, TEF, various tablet apps, NTi Minilyzer, NTi XL2, Bruel & Kjaer devices). A measurement device shall display a 20 Hz-to-20 kHz spectrum of audio in dB SPL at a minimum of 1/12 octave bands. A dual channel system capable of comparing a test stimulus audio source to a reference microphone input is preferred.

- Pre-amplifier/input device—Most real-time analyzers are software based. A quality microphone pre-amplifier/input device (e.g., Sound Devices USBPre2) is required to transfer the audio from the microphone to the computer or tablet device running the software.

Here's how to perform the test:

1. Using a pink noise generator, route the signal to a system input, matching the input sensitivity to achieve a unity gain signal.

2. Route the signal to the test software or RTA device (if it is a two-channel device that can show the difference between the test signal and the signal after routing through the system).

3. Connect a system output (line level or microphone level) to the test software or RTA device. If an output such as a record output is not available, use the final output device before the amplifier.

4. When viewing the difference between the two signals as a graph (transfer function), the frequency response should show a flat (+/– 0.5 dB) 20 Hz-to-20 kHz response curve.

To achieve an accurate test, any input equalization, high-pass filters, compression, or auto-gain processing should be bypassed. Output EQ, filters, compression, limiting, and bandpass gain or crossovers should be bypassed as well.

Refer to RaneNote 145 for an alternate testing method using a sine wave generator and a voltmeter.

Notes on Reporting

If possible, provide a software screen capture and submit it with the project test documentation.

AP-118 Audio System Equalization for Spectral Balance

Verify that the audio system equalization is in accordance with the acoustic response curves as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

This item covers the capability of an audio playback system to accurately reproduce the audio source device frequency response. The specific devices in the system coupled with the loudspeakers' acoustic properties and venue ultimately define the frequency response experienced by the owner/user/customer.

Project documentation shall define the system's measureable frequency response. In the absence of a defined target frequency response, the following limiting factors should be used to determine the measureable frequency response of the system:

- Source equipment—What is the specified frequency response of the source devices, (e.g., 20 Hz to 20 kHz, +/– 0.5 dB)?

- Loudspeaker response—While the source equipment may be capable of producing audio from 20 Hz to 20 kHz, the loudspeakers will be the primary limiting factor in what can be measured. An industrial paging horn is quite different in capability from a full-range multielement loudspeaker environment that may be able to reproduce audio outside the normal range.

- Environmental conditions—Temperature, humidity, air absorption, and surface acoustic properties —all affect the total system frequency response.

Other analog and digital system elements affect the final system frequency response and are referenced in other sections of this guidebook, such as system gain settings. For example, gain settings of amplifiers providing audio for separate frequency ranges in a three-way system can greatly affect the system frequency response. In this case, adjusting system gain would be the first requirement for correcting the frequency response prior to adjusting equalization, which would then reveal the final system frequency response.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	
5. Manufacturer Documentation	Rational Acoustics. 2010. *Anatomy of a Measurement Rig: Probes, Preamps and Processors.*
6. Other Best Practice Documentation	

Metric Selection

The system shall produce a frequency response of +/– 3 dB at a distance of 3.3 ft (1 m) on-axis across the frequency range of the loudspeakers under test. The upper and lower limit can also be expressed as the –3 dB point and –10 dB point referenced against the system's target SPL.

During testing, the design specification and the measured results should be recorded. The pass/fail status should also be documented.

In the absence of a design specification, measurements in three ranges shall be performed:

- 20 Hz to 20 kHz
- 50 Hz to 16 kHz
- 100 Hz to 14 kHz

Tests, Procedures, and Equipment

The following tests and their associated procedures are required to complete this verification item:

- An audio test source—A pink noise generator or sine wave sweep generator.

- Sound analyzer device—Many devices and software packages are available (SIA Smaart, EASE RA, TEF, various calibrated mobile apps, NTi Minilyzer, NTi XL2, Bruel & Kjaer devices). A measurement device shall display a 20 Hz-to-20 kHz spectrum of audio in dB SPL at a minimum of 1/12 octave bands. A dual channel system capable of comparing a test stimulus audio source to a reference microphone input is preferred.

- Measurement microphone—A small diaphragm condenser microphone (e.g., Earthworks M30) specifically designed for audio test measurements.

- Sound level calibrator—A device designed to deliver a test tone directly to the capsule of a test microphone at a specific SPL (e.g., Extech 407766). This allows the test system made up of a microphone, pre-amplifier or input device, and software to be calibrated to display and/or record exact SPL measurements during the test.

- Pre-amplifier/input device—Most audio analyzers today are software based. A quality microphone pre-amplifier/input device (e.g., Sound Devices USBPre 2) is required to transfer the audio from the microphone to the computer or tablet device running the software.

The test audio is routed to the audio system and the test software. The microphone picks up the test audio from the loudspeaker, which is also routed to the test software. The test software then displays two independent audio sources as two graphs or as the difference between the two.

Figure 6 A typical setup for a dual channel test
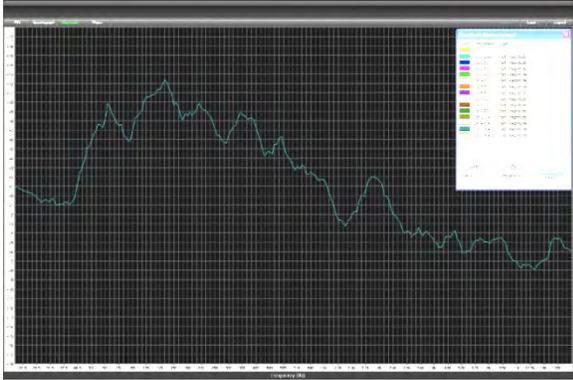
Figure 7 The result of a dual channel measurement of a system before any modification to the system frequency response
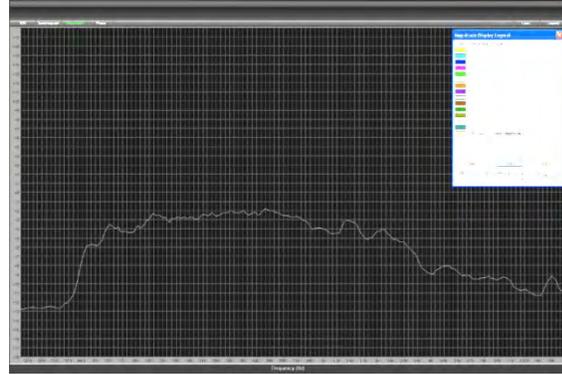
Figure 8 The same system after adjustments to the frequency response (EQ). The diagram displays an average of nine different microphone positions.

A minimum of four different microphone locations should be analyzed for frequency response. On axis shall be the primary location of the loudspeaker under test. Other positions shall reflect the range of listener positions within the venue.

Notes on Reporting

Provide a floor plan of the venue with each microphone test position labeled for reference to the frequency response diagrams.

Provide screen captures of each test location frequency response before any changes to the system EQ to establish a system baseline.

Provide screen captures of each test location frequency response showing the final system frequency response after equalization adjustments have been made.

AP-119 Audio System Latency

Verify that audio system latency meets requirements defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

This item measures the capability of a digital audio system to accurately sample and reproduce content within a defined amount of time. High levels of latency will cause detectable issues relating to audio performance, which is especially critical when audio is coupled with video display systems, requiring synchronization. Total system latency as a whole represents all applicable analog-to-digital (A/D) conversion, buffering, DSP, memory storage, and transport induced delays. It should be noted that not all devices would offer specifications on introduced latency.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	AES67-2013, *AES Standard for audio applications of networks—High-performance streaming audio-over-IP interoperability*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	

Metric Selection

Video lip sync:

- Undetected—+20 ms (audio advanced) and –40 ms (audio delayed)

- Slightly noticeable—+40 ms (audio advanced) and –60 ms (audio delayed)

- Noticeable—+60 ms (audio advanced) and –160 ms (audio delayed)

- Acceptable window—+90 ms (audio advanced) and –185 ms (audio delayed)

Audio-only monitoring of the system's live performance:

- Undetected—1.2 to 2 ms

- Slightly noticeable—2 to 5 ms

- Noticeable—5 to 10 ms

- Acceptable window—< 10 ms

Tests, Procedures, and Equipment

Using an audio signal test generator with a click or other fast transient noise source and an oscilloscope, compare the generator device timing with the system output's timing.

Network-based transport systems and over-the-air audio systems require the following equipment and software:

- Oscilloscope with dual trace

- MP3 or WAV files containing a click sound

- Software such as Pixel Instruments' LipTracker™

- Software such as Asaca's TuLips™

AP-120 Audio System Speech Reproduction at Listener Positions

Verify that the audio system provides speech reproduction (intelligibility) as defined in the project documentation. This verification item should require a metric to be verified.

Introduction

Installed audio systems should provide an adequate level of intelligibility as a basic requirement for effective oral communication. The most effective way to test to confirm that an installed system meets ineligibility requirements is to measure the speech transmission index (STI).

The process of achieving desired speech intelligibility should start early in the project where room shape, wall types, and finishes are designed as part of the architectural process. It is recommended that acoustical modeling software be used to verify metrics for spaces that have either a large mass or require a higher STI.

STI and common intelligibility scale (CIS) are measurements of the quality of speech transmission within a given space (see figure 9). STI for public address systems (STI-PA) is a more practical application of STI that allows for the measurement of public address systems in listening areas within a given space.

STI-PA measurements are used to determine the achieved level of intelligibility for public address systems to include fire life safety paging and supplementary mass notification systems. NFPA 72® and *Signaling Code Annex D* address intelligibility measurements, whereas CIS is referenced in NFPA 72 as an intelligibility measurement scale.

Figure 9 A comparison of CIS and STI scales

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	AS 1670.1:2004, *Fire detection, warning, control and intercom systems—System design, installation and commissioning—Fire* BS 5839-8:2013, *Fire detection and fire alarm systems for buildings* ISO 7240-16:2007, *Fire detection and alarm systems—Part 16: Sound system control and indicating equipment* NFPA 72®: 2013, *National Fire Alarm and Signaling Code*
2. Project Documentation	Pass/fail based on achieving minimum requirement for a given application and include a test report with test listening positions
3. InfoComm Standards	
4. Other Standards	ANSI S3.5-1997, *Methods for Calculation of the Speech Intelligibility Index* BS EN 60269-16: 2011, *Sound System Equipment—Part 16: Objective rating of speech intelligibility by speech transmission index* IEC 60268-16, *Sound system equipment—Part 16: Objective rating of speech intelligibility by*

	speech transmission index UFC 4-021-01, *Department of Defense DoD Uniform Facilities Criteria*	
5. Manufacturer Documentation		
6. Other Best Practice Documentation		

Metric Selection

Table 4 provides recommended STI ratings for various applications.

Table 4 STI ratings for a variety of applications (Republished with permission from BS EN 60268-16:2011·)

Category	Nominal STI value	Type of Message Information	Example of Typical Uses (for natural or reproduced voice)	Comment
A+	>0.76		Recording studios	Excellent intelligibility but rarely achievable in most environments
A	0.74	Complex messages, unfamiliar words	Theaters, speech auditoria, parliaments, courts, assistive hearing systems	High speech intelligibility
B	0.7	Complex messages, unfamiliar words		
C	0.66	Complex messages, unfamiliar words	Theaters, speech auditoria, teleconferencing, parliaments, courts	High speech intelligibility
D	0.62	Complex messages, familiar words	Lecture theatres, classrooms, concert halls	Good speech intelligibility
E	0.58	Complex messages, familiar context	Concert halls, modern churches	High quality PA systems
F	0.54	Complex messages, familiar context	PA systems in shopping malls, public buildings, offices, VA systems	Good quality PA systems
G	0.5	Complex messages, familiar context	Shopping malls, public buildings, offices, VA systems	Target value for VA/EWIS systems
H	0.46	Simple messages, familiar words	VA and PA systems in difficult acoustic environments	Normal lower limit for VA systems
I	0.42	Simple messages, familiar context	VA and PA systems in very difficult spaces	
J	0.38		Not suitable for PA systems	
U	<0.36		Not suitable for PA systems	

Note 1   These values should be regarded as minimum target values.

Note 2   Perceived intelligibility relating to each category will also depend on the frequency response at each listening position.

Note 3   The STI values refer to measured values in sample listening positions or as required by specific application standards.

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Tests, Procedures, and Equipment

Testing shall be performed in accordance with IEC 60268-16, *Notes on Reporting*, and/or ANSI S3.5-1997.

The test should be conducted in a completely finished space with the system in complete working order.

Tests should be conducted with an audio analyzer device such as an NTi Audio XL2 STI-PA MR-PROTest signal generator or approved equivalent. A detailed report should be provided with the following content:

- Indicate metric minimum STI-PA selection based on application using the metric table above or as identified in the project documentation.

- Identify listener areas and determine each sample listening/testing location.

- Document the locations and placement of the test microphone, speakers, and tests results for each sample listening location using detailed building plans.

- Document room temperature and humidity.

- Document room finishes and applied acoustical treatment.

Notes on Reporting

Note the result.

AP-121 Audio System Total Harmonic Distortion

Verify that the total harmonic distortion of the installed audio system is as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

This item measures the capability of an audio system to accurately reproduce content after passing through a single device or entire signal path without introducing any unwanted distortion. High levels of harmonic distortion will help reveal faulty equipment and improper gain structures. Audio harmonic distortion is a measurement of the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.

Metric Selection

Less than 1% is considered high fidelity.

Tests, Procedures, and Equipment

1. Use an audio test generator to produce a 1 kHz sine wave at the input of a device or system.

2. Perform a spectral analysis on this signal (using a spectrum, or Fast Fourier Transform [FFT] analyzer) examining the output for evidence of any frequencies other than the one applied.

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In addition to the original input sine wave, if there are frequencies arriving at harmonic intervals of the input frequency (i.e., 2x, 3x, 4x, 5x, 6x, 7x, 8x), a metric can be derived.

3. Using a spectrum analyzer to obtain the level of each harmonic, perform a root mean square (RMS) summation. This can usually be done automatically with more advanced test equipment.

The level is divided by the fundamental level and cited as the total harmonic distortion percentage.

Notes on Reporting

Since individual harmonic amplitudes are measured, it is required that the tester disclose the test signal frequency range, level and gain conditions, and number of measurements taken.

AP-122 Conferencing Audio Levels

Verify that in a conferencing audio application, the incoming and outgoing audio levels are checked and adjusted in the system as defined in the project documentation. This verification item should require a metric to be verified.

Introduction

In typical conferencing systems, many different people and sites join the call. These participants in a multipoint call could be using anything from a mobile phone to a fully installed room system. While many online audio/video bridging systems have an automatic volume-leveling feature, others leave that to the individual participants. A best practice when designing and integrating room systems that participate in multipoint calls within a system is to ensure all audio levels are set to a standard reference point. This practice typically involves calling out to a dedicated site designed to provide feedback on the audio levels going in or out of a particular room.

Adjusting all potential participating rooms to a standard audio reference should eliminate the need for participants to constantly raise or lower volumes to ensure everyone is heard. Many university organizations provide this service to all participants in the conferencing system.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	AP-114 Audio Coverage in Listener Areas AP-116 Audio Level Exceeds Background Noise Level AP-118 Audio System Equalization for Spectral Balance AP-120 Audio System Speech Reproduction at Listener Positions

4. Other Standards	
5. Manufacturer Documentation	
6. Other Best Practice Documentation	

Metric Selection

The system designer should investigate if the organization using the conference facilities utilizes a standard adjustment site or specific audio settings. Reference to this site should be made available to the integrator setting up the room. In the absence of a reference site, use a VTCTest produced by Gary Miyakawa, Inc., 71.14.2.157(HDX) and 71.14.2.158(HDX).

The VTCTest checks audio and video in both directions. It also checks for H.239 (dual video) and offers a callback test.

Tests, Procedures, and Equipment

A standard reference point should be used to calibrate audioconference levels arriving in the room or being sent from it. An audio signal coming from the far side should feed to the audio or video codec. A far-side signal should include a playback of an audio tone (pink noise) and human voice transmitted at 0 dB as referenced within the audio digital system processing (DSP) system and/or codec to aid in level adjustment. The reference point should also contain a method to measure the signal being sent from the local room.

Each system should then be adjusted fully to local specifications found in other areas of the verification standard, such as AP-114 Audio Coverage in Listener Areas. Each additional room within an enterprise-wide conferencing system should call in to the same reference point to receive the far-side signal and adjust accordingly.

The incoming far-side signal should be adjusted to 0 dB, as referenced within the audio DSP system and/or codec from a standard test site. All uses of that audio signal would then be adjusted as required by local in-room tests. All inputs to the system (e.g., microphones and other sources) should be adjusted to achieve 0 dB, as referenced at the output of the audio DSP system. The outgoing audio should be adjusted to 0 dB, as referenced in the audio DSP and/or codec and verified by the same standard test site.

Notes on Reporting

Documentation that verifies the observed testing procedures and readings should be included in the system verification report.

AP-123 Conferencing Echo Suppression Performance

Verify that a system with conferencing capability performs at nominal operating levels in a full duplex mode with echo and latency performance as defined in the project documentation.

Introduction

In an audio/videoconferencing environment, acoustic echo is the experience of hearing your voice return to you through the audio system. In a system with even minimal delay, the phenomenon can cause a complete breakdown of the conferencing environment. This is not to be confused with reverberation, which is caused by room acoustics and refers to the sound that may bounce off hard surfaces in a room, creating multiple reflections of the original audio signal.
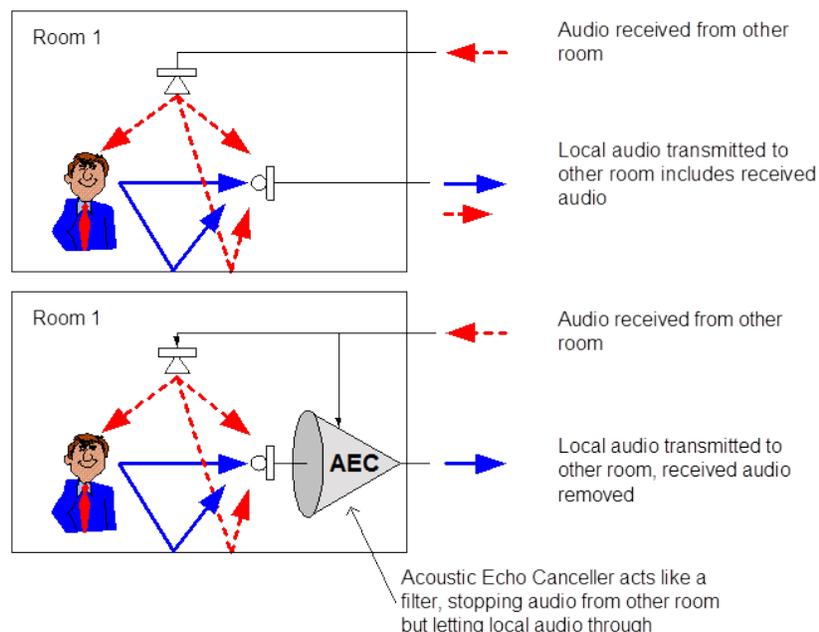
Figure 10 Acoustic echo canceller (Courtesy of Polycom)

If acoustic echo is audible on a conference call, the issue is on the far-side of the call. In a multipoint call, the site that hears no echo is the one that has the problem. Muting that problem site can allow the conference to continue with limited functionality. However, eliminating this acoustic echo is critical to the success of any conferencing environment.

Current capabilities of DSP-based acoustic echo cancellers (AECs) in installed room environments are very good. Most issues with acoustic echo are due to the improper setup of the audio system. For the AEC to work properly, it must have a clear reference signal of the audio coming from the far side. The goal of the AEC is to identify and eliminate any of this reference signal that may reside in an audio signal going out of the local room. For instance, if the reference signal is too low for the AEC to get a good picture, the AEC will not be able to eliminate the acoustic echo properly.

Metric Selection

In practical terms, no amount of perceptible acoustic echo is acceptable from an installed room system. The AEC will work to digitally eliminate any elements of the reference audio signal from the outgoing audio signal. In technical terms, some acoustically difficult rooms may cause acoustic echo to be present for short periods of time as the acoustics of the room change (people move or doors open and close) and the AEC must adapt.

Metrics may be developed to determine amounts of acoustic echo that may be allowed during this adaptation stage. In any case, this effect should not remain perceptible (less than 55 dB of cancellation) for more than 200 ms during full-duplex operation (i.e., both sides speaking simultaneously). It is preferable and achievable that the system never experience acoustic echo under any condition. Proper room acoustical treatments and placement of microphones will have a significant impact on the AEC operation.

Some additional settings that will assure the AEC will work properly in the installed room are:

- Audio used in a reference signal should be post-process audio. The cancellation reference should be a sample of the signal being sent to the power amplifiers.

- Avoid routing far-end audio through dynamic feedback controllers. This could give a false acoustic picture of the room to the AEC.

- As the audio signal is acquired from a microphone, assure the AEC function is completed prior to any automatic gain control, noise canceling, muting, or microphone mixing. Applying any of these functions prior to the AEC activity could cause a false acoustic picture of the room.

Ensure that the AEC has a strong signal of the incoming audio as a reference. An incoming signal that is weak could cause the AEC to miss elements that should be eliminated from the outgoing signal.

Tests, Procedures, and Equipment

Testing for AEC operation is best performed on a hard-wired telephone handset calling from outside (far-side) of the integrated room being evaluated. Using a handset is preferred because it allows a better detection of anomalies. Mobile handsets could introduce elements that would confuse the results and should not be used for this testing. A wideband signal is also preferred to detect anomalies in all frequencies. If the system cannot call in from a wideband telephone system, a video call can be made using a headset.

Place a call into the room being tested from a far-side system. Far-side participants should be able to speak at various levels without hearing their voices echo back through the call. Additional testing should include both sides speaking at the same time to gauge the echo canceller's full-duplex performance.

Notes on Reporting

Any acoustic echo anomalies should be noted, with specific reference to parameters in which the echo occurs. It is essential to know which far-side signal was affected (i.e., video, telephony) and through which microphones.

AP-124 Loudspeaker Impedance

Verify that all loudspeaker circuits have the correct impedance as defined in the project documentation. This verification item should require a metric to be verified.

Introduction

Testing a loudspeaker for the proper impedance can reveal wiring issues, or problems within the loudspeaker itself before connecting amplifiers. Catching impedance issues before running sound to the loudspeakers can prevent damage to the amplifier or loudspeakers. It is important to consult the system documentation for the expected impedance characteristics of the system under test.

Tests, Procedures and Equipment

First, calculate the expected impedance of the system.

Using an impedance testing device specifically designed for loudspeaker systems, test each loudspeaker cable at the amplifier by first removing the loudspeaker cable from the amplifier outputs. Recommended test devices include the GoldLine ZM series of test units and the TOA ZM-104A. The GoldLine unit produces test tones at 100 Hz, 330 Hz, 1 kHz, and 10 kHz, allowing the testing of elements within a multi-driver loudspeaker.

Follow these steps to perform the measurement:

1. Disconnect the wires from the amplifier.

2. Calibrate the meter:

    *   Connect the test leads to the meter.

    *   Select the scale that is appropriate for your expected value for greatest accuracy.

    *   Hold the test leads together so the tips are touching, or press and hold the zeroing button.

    *   Rotate the calibration knob until the reading indicates 0 (zero).

3. Connect meter leads at the first loudspeaker. Connect one lead to each wire on the first loudspeaker in the chain (polarity is not important).

4. Observe the reading and compare it with the expected reading. It should be similar to the predicted impedance. A tone should be heard through the loudspeakers that are being measured. Hearing the tone is a good indicator that, overall, the wiring is good.

5. Reconnect the loudspeaker wires and power on the amplifier.

When working with large systems, check the line impedance often. Do not wait until all of the loudspeakers are wired and the scaffold is down to find out that one of the loudspeakers is bad. As you install a group of loudspeakers, test it to make sure there are no problems before you install the next group. Write down the final measured impedance, which will be very useful for future system service and maintenance.

Metric

The metric depends on the design. The example given reflects a particular combination of amplifier power, voltage, and number of speakers. Since this is different in every design, the metric is that the measured impedance isn't below the calculated impedance.

Notes on Reporting

Create a spreadsheet listing each loudspeaker cable by wire number and system, the resultant impedance measurement, and the test frequency. Note any impedance measurements that fall outside the expected range presented in the system documentation.

AP-125 Microphone Physical Alignment and Placement

Verify proper alignment and placement of microphones in the system as defined in the project documentation.

Introduction

This item verifies the physical setup of microphones rather than the electronics of the system. Answering the following questions helps to complete the verification:

- Are the microphones in the locations specified in the system documentation?

- Are the microphones close enough to the person speaking (i.e., is the local talker louder compared with the background noise)?

- Are the microphones aimed in the proper direction?

- Is the proper microphone type used in the right location (e.g., cardioid, omnidirectional)?

- Are the microphones directed away from loudspeakers with proper distance to avoid feedback?

- Are rooms with movable furniture suitably outfitted?

- Are ceiling microphones installed in low-noise environments where they can pick up the local talker louder than the background noise.

NOTE The verification of this item may uncover problems that often are a result of poor coordination between the AV designer, mechanical engineer, and interior designer, which may not be immediately apparent until the rooms are built. It is considered best practice to review the premise of the design in the actual room prior to installation and provide the consultant, end user, and/or owner a sound check of the options prior to final installation. Many factors can be discovered with this simple process, avoiding costly modifications.

The *Audiovisual Design Reference Manual* (AVDRM) sections 17-32 to 17-41 outline in detail best practice for this item, and a summary is provided as follows:

To set achievable expectations, the audio quality of a ceiling microphone should be tested in the target room as early in the design process as possible. With the use of a microphone amplifier and powered loudspeaker, the customer can listen to the audio quality and judge if it is acceptable before additional work is performed. More often than not, once the conference room users hear the resulting sound quality of ceiling microphones, they opt for tabletop boundary microphones or, at the very least, decide to place the microphones closer to the local participants. Ceiling microphones should be installed away from HVAC, light fixtures, projectors, loudspeakers, and any other noise sources. If ceiling microphones are the only option, they should be hung from the ceiling close to the talkers, rather than flush-mounted.

Tests, Procedures, and Equipment

No specific tests are required. Check pickup patterns and locations against the system specifications. Ensure handheld, lavalier, wireless, and other non-fixed microphones in the system are provided and tested.

Notes on Reporting

No specific reporting guidelines are recommended.

AP-126 Microphone Gain Before Feedback

Verify that the speech reinforcement system is operating without feedback and at audio levels as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

An audio system should be designed to produce enough volume so that the presenter is easily heard and understood. The issue that commonly arises is the presence of feedback.

This item tests to verify that microphones can be used at nominal levels without creating feedback. The principles of potential acoustic gain (PAG) and needed acoustic gain (NAG) calculations are necessary during the system design phase. If the sound from the loudspeaker arrives at the microphone at a level higher than the original sound at the microphone, feedback occurs.

Tests, Procedures, and Equipment

Set a microphone in the space where it will normally be used. Unmute the microphone and set it to produce a sound level in the audience area based on the system documentation. The system documentation should also indicate the required headroom of the system beyond the normal use setting.

Connect a pink noise source into the room and play it back in the audience at a level equal to the necessary microphone dB level. Upon muting the pink noise, no additional feedback or ringing shall be detected. Unmute the noise source and raise the level at 3-dB increments, muting each time to determine if feedback is present.

Metric

When feedback is detected, a spectrum analyzer should reveal the specific frequency. This frequency may be attenuated with a filter to raise the microphone headroom before feedback. At some point, adding too many filters really just results in lowering the microphone gain. So, this should only be done sparingly.

If the system is normally used with multiple microphones or a wireless microphone that could be placed in many locations, run a test accounting for those variables. Generally, each doubling of the number of open microphones at any one time reduces the system headroom by 3 dB.

Notes on Reporting

List the headroom in dB above the standard operating volume at which feedback occurs. Alternately, list the maximum sound pressure level generated in the listening area before feedback.

AP-127 Microphone Level Alignment

Verify calibration of microphone inputs so that the difference between any input signal level after the first common gain adjustment meets the requirements of the project documentation. This verification item should require a metric to be verified.

Introduction

Verify the calibration of microphone inputs so that the difference between any input signal level after the first common gain adjustment meets the requirements in the project documentation.

Metric Selection

The best case is 0 dBu level for each microphone. The maximum allowed range is +/– 1 dB variation. It may vary based on the type of equipment and the meter scale.

Tests, Procedures, and Equipment

Ensure connections to microphones are in place and tested. Microphone should be connected to an analog mixer, a digital mixer, or a DSP unit. This test should be carried out in conjunction with AP-126 Microphone Gain Before Feedback to achieve desirable performance parameters.
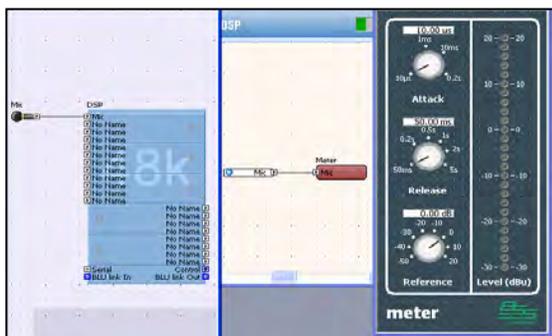
Figure 11 Gain adjustments on a DSP

Figure 12 A peak program meter indicating 0 dBu

Tests

Microphones should be connected to either one of the signal processing units, similar to mixing consoles or a DSP. Each channel should have individual pre-amplifier gain control to adjust the incoming signal level. The input on the signal level meter should read 0 dBu to match all microphone levels (see figures 11 and 12).

Procedures

A person should stand at 1 m (3.3 ft) from each talker position in the room. Each person should be made to talk at about 60 dB SPL into each microphone. Adjust the settings on the pre-amplifier gain controls to produce a 0-dB level at the input of the mixer bus.

Equipment

The testing equipment shall consist of:

- Microphones that are normally used in the space.
- DSP or mixing consoles with individual mixer channels.

It is also critical to have a person who can talk at the same pace and same pitch.

Notes on Reporting

All applicable microphones should have similar characteristics (e.g., polar pattern). Physical inspection for any defects should be completed.

The automatic gain control (AGC) feature, found in many DSPs, should be disabled.

These tests are performed at the input signals and should not be verified by listening through loudspeakers.

AP-128 Multi-channel Loudspeaker System Output

Verify that the audio outputs of a multi-channel loudspeaker system are assigned correctly to designated outputs as defined in the project documentation.

Introduction

There are two possible application of this verification item:

- Application 1 involves verifying that the loudspeakers in a surround-sound audio system are wired so that audio intended for a particular loudspeaker is in fact originating from that loudspeaker.

- Application 2 involves verifying that the bi-amped or tri-amped loudspeakers have the audio passband intended for the particular driver routed to the correct driver.

Tests, Procedures, and Equipment

Many surround-sound receivers and processors (application 1) have built-in test generators that cycle a test tone through each output of the device. A number of test DVDs exist with audio routed to each specific output and can also be used to test. If a DSP unit is involved, test tones can easily be routed to each speaker.

For application 2, the best method is to play a tone within the appropriate passband of the driver under test through the system while muting all other outputs. Using a multimeter, verify that the speaker wire for the driver under test has the test tone. Running a 1K tone to a miswired line that delivers it to a woofer instead of a mid-range driver would still produce a tone and, in such a case, a casual ear test would be misleading.

Notes on Reporting

Provide a spreadsheet identifying each loudspeaker or driver and reporting whether they passed the test.

AP-129 Sound Masking

Verify that audio system sound-pressure levels and equalization are adjusted to the level of sound masking as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

This item measures the capability of a sound masking system to effectively mask speech intelligibility. Three indexes help to determine the effectiveness and acceptability of speech-making systems:

- Articulation index (AI) from ANSI S3.5-1969 is calculated based on the measurement of how loud a conversation is relative to the background sound levels in a space on a scale of 0 to 1 (0 to 100 percent), representing how well a person can understand speech.

- Speech intelligibility index (SII) from ANSI S3.5-1997 is an updated AI version that involves predetermined speech and background noise levels. Calculated as a percentage, the highest levels represent the most intelligible speech.

- Speech privacy index (PI) is covered in ASTM E1130-08 and is derived from the results of AI or SII. The formula to calculate is PI = (1 − AI) 100 or PI = (1 − SII) 100. The resulting percentage is representative of what a person is not able to understand or the inverse of AI or SII. The metric derived from PI is better understood as it is a positive representation of expected privacy. PI may be misleading about the level of privacy because it does not take into account low-level speech.

Familiarity with each index set will help you to select the correct metric.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	ANSI S3.5-1969 and ANSI S3.5-1997, *Methods for Calculation of the Speech Intelligibility Index* ASTM E1110-06, *Standard Classification for Determination of Articulation Class* ASTM E1130-08, *Standard Test Method for Objective Measurement of Speech Privacy in Open Plan Spaces Using Articulation Index* ASTM E1179, *Standard Specification for Sound Sources Used for Testing Open Office Components and Systems* ASTM E1573-09, *Standard Test Method for Evaluating Masking Sound in Open Offices Using A-Weighted and One-Third Octave Band Sound Pressure Levels* ASTM E2638-10, *Standard Test Method for Objective Measurement of the Speech Privacy Provided by a Closed Room* IEC 60268-16, *Standard Specification for Sound Sources Used for Testing Open Office Components and Systems*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	

Metric Selection

Articulation Index

The range is divided into four qualitative privacy categories:

- Confidential (0.00 to 0.05)

- Normal (0.05 to 0.20)

- Marginal (0.20 to 0.30)

- None (0.30 to 1.00)

Privacy Index

The range is divided into four qualitative privacy categories:

- Confidential (95 to 100 percent)

- Normal (80 to 95 percent)

- Marginal (70 to 80 percent)

- None (0 to 70 percent)

Tests, Procedures, and Equipment

Refer to ASTM E1573-09 or ASTM E1130-08 for guidance when measuring open office spaces. Refer to ASTM E2638-10 for guidance when measuring closed room spaces. When following the above standards, verify that the use of equipment conforms to ASTM E1179 and ASTM E336-07.

Here is a basic procedure for measuring the parameters of sound masking:

1. Perform a spectral analysis within the space (using a spectrum or Fast Fourier Transform [FFT] analyzer) examining the background noise for a 30-s minimum, with no other noise sources present or generated.

2. Use an audio test generator, amplifier, and loudspeaker to produce broadband pink noise or simulated speech into a space at referenced levels in dB.

3. Perform a spectral analysis within the space (using a spectrum or FFT analyzer), examining the source noise for a 30-s minimum.

Notes on Reporting

When reporting on this item, include the following elements:

- Facility location

- Identification of the acoustic instrumentation (manufacturer, model, and serial number) and the last calibration date

- Names of the persons conducting the measurements

- Date and time of each measurement

- Microphone location for each measurement

- Definition of whether the measurement microphone was handheld or mounted on a tripod

- General description of the room including room name or number and approximate floor area

- General description of the surface treatments and the room occupancy

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- General description of the HVAC system, including operating conditions and room temperature

- General description of whether windows or doors are open and origin of any intruding noise

- Description of surface treatments of walls, ceilings, and floors, as well as furniture and other materials within the space

- Average (Leq) octave band sound pressure levels for each measurement location

- Measured noise criteria rating for each room

AP-130 Audio Reinforcement System Headroom

Verify that the audio system is capable of performing above nominal operating levels without distortion as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

The main requirements for a speech or program audio system are that it is:

- Loud enough

- Intelligible

- Stable

Headroom addresses the third requirement—how loud the audio level can be when adjusted to full and still be free of distortion. It measures the ratio of the largest undistorted signal that can be passed through a unit or system and the average signal level. For example, if the average level is +4 dBu and the largest level is +26 dBu, there is 22 dB of headroom.

Many designers prefer to keep a narrow range of levels so users cannot put the system into feedback. Others want the ability and flexibility to have complete control of the system. This needs to be determined in the project documentation.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	

5. Manufacturer Documentation	
6. Other Best Practice Documentation	InfoComm/BICSI *AV Design Reference Manual First Edition,* Chapter 3: Audio Signals and Chapter 17: Systems.

Metric Selection

System designers should calculate critical distance. When microphones are used in the system, potential acoustic gain (PAG) and needed acoustic gain (NAG) calculations are needed to determine system headroom. This is called feedback stability margin (FSM). For speech reinforcement, an FSM of 6 dB is common. For program audio, the FSM is typically 12 dB. If the design allows for enough gain and it meets the customer requirements by equaling or exceeding NAG, the audio system will perform properly.

Here's an example of some considerations for a conferencing space:

- The measured ambient noise in the space is 45 dB SPL.

- The required speech level is 62 to 68 dB SPL or 15 dB above the measured ambient noise.

- The required program audio level is 70 to 75 dB SPL or 20 dB above the measured ambient noise.

- Minimum target headroom would be 10 dB above normal operating level (speech or program)

Tests, Procedures, and Equipment

Using a sound meter (dB-SPL, A-wtd, slow):

- Refer to system target speech and program levels per system specifications.

- Carry out the test with limiters disabled.

Using a test tone (sine wave, 1 kHz), adjust the system to the maximum achievable volume without distortion, and measure the audio level.

Perform the tests on each audio input to the system and document the results.

AP-131 Audio System Signal-to-Noise Ratio

Verify audio system electrical signal-to-noise ratio meets the minimum levels defined in the project documentation. This verification item should require a metric to be verified.

Introduction

This item measures the power or amplitude ratio of an audio signal to noise after passing through a single device or entire signal path. The system or device is typically measured with no signal present (noise) and then again with a defined signal level and bandwidth (signal). The signal is generally a 1 kHz +4 dBu (IEC 60268-17) or 1 kHz 0 dBu signal, with measurements taken at the same location within the system. A simple RMS multimeter is suitable for taking measurements.

Formula for power (RMS):

$$SNR_{dB} = P_{signal,dB} - P_{noise,dB}$$

Formula for amplitude (RMS):

$$SNR_{dB} = 20log_{10}\frac{A_{signal}}{A_{noise}}$$

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	IEC 60268-17, *Sound system equipment—Part 17: Standard volume indicators*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	InfoComm/BICSI *AV Design Reference Manual First Edition,* Chapter 3: Audio Signals and Chapter 17: Systems

Metric Selection

Example:

S/N = 90 dB ref +4 dBu, 22 kHz BW, unity gain

Applications

Type	SNR
Plain old telephone service (POTS)	40 dB
AM Radio/LP records	50 dB
FM radio, cassette player	70 dB
CD player	90 dB
Human ear range (instantaneous)	85 dB
Hi-Fi studio recording equipment	120 dB
Human ear range (total)	120 dB

Tests, Procedures, and Equipment

Using an audio test generator and RMS multimeter:

1. Insert a measurement signal into the system

2. Measure the signal at the specified point

3. Remove the measurement signal

4. Measure noise at the specified point

Notes on Reporting

Metrics should include the measurement values, reference level, bandwidth, filters, and gain settings of the system under test.

Video System Performance

Verification items within this category verify the video system's performance, stability, and conformance to requirements provided within project documentation. Project-specific verification items that address capture, transformation, or reproduction of video; video signal management; and camera operations shall be listed in this section.

VP-100 EDID Management Plan

Verify that the EDID (Extended Display Identification Data) management plan has been implemented per the project documentation.

Introduction

EDID is the means by which a display and a source communicate to determine the most appropriate resolution to be provided by the source. While displays usually can support and many sources can provide many different resolutions, typically only a small set of resolutions perform matchups, and some believe only one resolution is appropriate.

The project documentation shall list the preferred system resolution for each individual system in the project. In addition to the preferred resolution, a secondary list of acceptable resolutions shall also be given. For example, the system resolution may be listed as 1920×1080, with acceptable resolutions of 1280×720, 1600×900, 1080p, and 720p.

In addition to resolution, EDID carries information concerning the required audio format of the display device. This may adversely affect the system if a display is asking for 5.1 surround audio when the system is set to route two-channel audio. Examining the EDID can reveal issues such as these.

Tests, Procedures, and Equipment

A list of systems resolutions from the project documentation shall be verified by connecting a computer or test generator that can read EDID to each system input and routing that input to each display. List the source-to-display combination that reveals a resolution contained in the system documentation but not supported by that combination.

It is recommended that a copy of software that reads and displays the EDID information is used to see the actual data being sent to a source. This is possible for any HDMI, DVI, Displayport, or VGA connection with software like EDID Manager from Extron Electronics or

Monitor Asset Manager from EnTech. Some video test generators can also read and display the display device's EDID information.

The test computer or test generator shall be connected to each system input. The input shall be switched to the display and the EDID data shall be loaded with the EDID manager software. A quick visual inspection can help to determine if there are EDID issues before looking at the software. The following questions will assist with the verification:

- Did the computer shift to the correct resolution when plugged into the input?

- Is the color space correct? (If the colors look green, then the EDID may be expecting an RGB color space while the source could be sending a component color space.)

Under the Full View tab of the EDID Manager software, bytes 54-71 list the display's Preferred Detailed Timing.

In addition to the preferred detailed timings, check the display manufacturer. If there is switching or routing equipment between the source and the display, that equipment may have hijacked the EDID path. If you are using a Panasonic projector and the EDID is showing KRA as manufacturer, a Kramer switcher or router is providing the EDID information. This may be appropriate or not depending on the design intent of the project. Many advanced digital matrix units have the ability to create their own EDID tables, which generally speeds up the switching process and provides a way to narrow down the different resolution possibilities to the resolutions necessary for that particular project.

The EDID data also lists established timings representing the acceptable resolutions that the display can support. Any system resolutions listed in the documentation should be present in the list of established timings.

This process shall be repeated for each input to all displays.

Notes on Reporting

Use a spreadsheet to create a grid showing inputs in rows and displays in columns. Title such a grid according to the resolution found in the system documentation. A separate grid should be used for each resolution listed in the project documentation. An example is shown in the following table.

Table 5 Sample resolution grid spreadsheet

1920×1080	Description	Projector 1	Projector 2	Confidence Monitor 1	Confidence Monitor 2	Podium Monitor	Lobby Digital Signage Monitor
Description	Input/Output	1	2	3	4	5	6
Laptop 1	1	PASS	PASS	PASS	PASS	FAIL	FAIL
Laptop 2	2	PASS	PASS	PASS	PASS	FAIL	FAIL
Blu-ray Player	3	PASS	PASS	PASS	PASS	PASS	FAIL
Lectern PC	4	PASS	PASS	PASS	PASS	PASS	FAIL
Digital Signage	5	PASS	PASS	PASS	PASS	PASS	PASS

VP-101 HDCP Management Plan

Verify that the HDCP (High-bandwidth Digital Content Protection) management plan has been implemented as defined in the project documentation.

Introduction

The purpose of this verification item is to document the ability of a system to accurately display encrypted content at the appropriate output displays/devices. It is also to verify that the HDCP-encrypted content is not delivered to devices that are not HDCP compliant.

A best practice for this item is that the designer specifies which input devices in the system are intended to be HDCP compliant and which output devices are not HDCP compliant and tabularize them so that the AV contractor could minimize routing issues.

Tests, Procedures, and Equipment

Using a known encrypted video source (a Blu-ray disc of a major motion picture), play content into the video system. Route the content to all display devices and output destinations. Verify that the content is visible on all HDCP compliant displays. Verify that the content is not visible on all non-HDCP-compliant devices (e.g., VC codecs, recording devices).

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

VP-102 Projected Display Physical Alignment

Verify that the combined installation of projector and screen provides a displayed image that is correctly aligned to the active projection screen surface without misalignment unless an alternative condition is specified in the project documentation.

Introduction

This item requires verification to ensure that the projected image is correctly aligned with the projection surface on which it is intended to project. In its simplest form (and in the majority of cases), when a rectangular image is projected onto a rectangular screen, such verification consists of ensuring that the image fully and squarely fills the screen.

This verification should ensure that there is no unintentional overscan or underscan and that the edges of the image align with the edges of the projection surface (i.e., that the image is not at an angle to the screen). The projection aspect ratio should also be checked to ensure it matches the screen.

In situations where a non-rectangular projection surface is used, this item still applies, but the testing process requires custom test patterns.

This item should be verified in conjunction with VP-104 Image Geometry.

Tests, Procedures, and Equipment

The simplest form of test for a rectangular screen entails projecting either a flat white field or a grid test pattern onto the intended screen surface. The alignment of each edge of the image should be verified against the edge of the projection surface. Any specified overscan should be measured and recorded; otherwise, each image edge should be checked to ensure it is aligned and square to the edge of the projection area.

If using a non-rectangular image area, create a custom test pattern to match the template that will be used for content creation. All edges of such a shape should be checked for physical alignment between the image edge and the projection surface edge.

If using projection mapping, edge blending, or similar techniques, this item would verify basic projector aim alignment in accordance with the project requirements. The final projection image alignment would be covered under VP-104 Image Geometry.

Notes on Reporting

A photograph attached to the verification report showing the image alignment provides a helpful record.

VP-103 Video System Pixel Failure Tolerance

Verify that all displayed images do not have pixel failures (bright or dead pixels) that exceed the requirements of the project documentation or the manufacturer's specifications. This verification item shall require a metric to be verified.

Introduction

The designer should specify the maximum allowable number of pixel defects in the project documentation. The person verifying the system performance should compare the minimum allowable pixel defects against the manufacturer's specifications.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	ISO-9241-300:2008, *Ergonomics of human-system interaction—Part 300: Introduction to electronic visual display requirements*

5. Manufacturer Documentation	
6. Other Best Practice Documentation	

Metric Selection

The designer should specify the maximum pixel defects allowed. The decision may be driven by how critical the use is, such as when very detailed viewing is required by certain medical applications.

When the design criteria for pixel failure tolerances is not stated or known, the person performing the testing should refer to the manufacturer's specifications to ensure the flat panel is performing according to the specifications to which it was built.

Tests, Procedures, and Equipment

Using a video test generator and a full white test signal, perform a visual inspection of the displayed image to verify that there are no full dark pixels or discolored pixels due to sub-pixel failure.

Notes on Reporting

This item requires documentation of any defective pixels or sub-pixels plus pass/fail status.

Supplemental Information

ISO-9241-300: 2008 offers guidelines for defining the classification of panels with the allowable numbers of pixel defects (see information below) and the types of pixel defects.

The three types of pixel failures are:

1. Full bright (always white) pixel

2. Full dark (always black) pixel

3. Defective sub-pixel (red, green, blue)

There are four classifications for pixel faults and each has its tolerances for allowable pixel defects:

- Class 0—Completely defect free (no full pixel or sub-pixel defects)
- Class 1—Including any or all of the following:
    - 1 full bright pixel
    - 1 full dark pixel
    - 2 single or double bright or dark sub-pixel defects
    - 3 to 5 *stuck on* or *stuck off* sub-pixels (depending on the number of each)
- Class 2—Including any or all of the following:
    - 2 full bright pixels

- 2 full dark pixels

- 5-10 single or double bright or dark sub-pixels (again, depending on the number of each, no more than 5 bright "stuck on" sub-pixels are permitted)

  ▪ Class 3—Including any or all of the following:

- 5 full bright pixels

- 15 full dark pixels

- 50 single or double sub-pixels stuck on or off (allowed pixel defects per one million pixels in the TFT/LCD matrix)

VP-104 Image Geometry

Verify that all displayed images are correctly focused, have the correct image geometry and are free from distortion (e.g., stretching, keystone, barrel/pincushion). Any requirements for projection mapping or image shaping to unusual surfaces should be validated in accordance with the requirements of the project documentation.

Introduction

This item requires verification to ensure that the geometry of all displayed images is correct. This item applies to all displayed images regardless of how they are produced. It applies to projection, flat panel displays, LED panel displays, projection-mapped surfaces, LED curtains, and every other form of displayed image produced by an AV system.

In the more usual case of a flat rectangular image, this item verifies that all displayed images have the correct image geometry and are free from distortion such as stretching, keystone, and barrel/pincushion.

This verification must be carried out on a completed aligned system. VP-102 Projected Display Physical Alignment is a prerequisite to this item when projection is used.

When projection mapping, edge blending, or other complex arrangements are in place, the overall perceived image geometry should still be verified in accordance with the project documentation to ensure that the viewers will perceive the correct image from the intended viewing area. It is essential that any image processing systems have been commissioned and configured prior to verification of this item. Viewing assessments from multiple locations may be required for such systems.

In situations where an irregular surface is used, this item still applies, but the testing process requires custom test patterns.

Tests, Procedures, and Equipment

The simplest form of test for a flat rectangular display entails displaying a grid test pattern onto the intended display surface. The image geometry should be checked to ensure that the aspect ratio of the rectangles (or squares) is maintained and that the image remains linear and regular, without curves or other distortions.

A test pattern with circles should also be displayed to ensure the circles retain their correct shape and are not squashed or stretched. Most standard test pattern generators can provide these patterns.

The system should be tested initially at the native resolution of the display, and subsequent tests should be made at all intended operating resolutions of the system.

If projection mapping, edge blending, or similar techniques are used, this item would verify the overall geometry of the final displayed images, once all image processing has been configured. Similar grid test patterns should be used, passing through the processing systems to give the final results on the display surface. The image should be viewed from multiple locations within the defined viewing area to ensure the best experience.

Notes on Reporting

A photograph attached to the verification report showing the image geometry provides a helpful record.

VP-105 Displayed Image Performance

Verify that the components of the displayed image system(s) (projection or direct-view) perform(s) as required with relation to image size, viewing angles, sight lines, viewer locations and/or any other requirements as defined in the project documentation.

Introduction

This item is to verify that the display system is performing as defined in the project documentation. Specific elements of the image need to be evaluated, including but not limited to image size, viewing angles, sight lines, quality, and clarity.

Tests, Procedures and Equipment

Verify each of the following as part of the evaluation for this item:

- The image size matches the size specified in the project documentation.
- All displays are located such that all viewing angles are as specified in the project documentation.
- There are no obstructions or other conflicts with sight lines from each viewer position.
- The viewer locations meet the system requirements as defined in the project documentation.

Using a signal source, input various source materials into the display system.

Evaluate the performance based on system requirements as defined in the project documentation. In the absence of project documentation, best practices for viewing angles and sight lines are defined in the BICSI/InfoComm *Audiovisual Design Reference Manual* (AVDRM).

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

VP-106 Colorimetry

Verify calibration of all video displays to ensure they display colors uniformly to a common reference standard as defined in the project documentation.

Introduction

Correct video colorimetry allows for video content to be delivered accurately on a single display, and uniformly across multiple displays. Typically the white point/color temperature or a requirement for uniform color will be defined in project documentation. Using test patterns such as HD SMPTE or ARIB setup of brightness, contrast, chroma, and hue can be adjusted to obtain the correct colorimetry. It is possible to have a display setup with advance software and sensors or simply your eyes and blue filter glasses (Wratten 47B).

Refer to the following sources for additional information:

- European Broadcasting Union (EBU) Tech. 3213-E: 1975, *EBU Standard for Chromaticity Tolerances for Studio Monitors*

- The Society of Motion Picture and Television Engineers (SMPTE) RP 145, *SMPTE C Color Monitor Colorimetry*

- International Telecommunication Union Radiocommunication Sector (ITU-R) BT.709-5 (04/02), *Parameter values for the HDTV standards for production and international programme exchange*

- Federal Communications Commission (FCC), NTSC (1953) Color Space

- International Organization for Standardization (ISO) 10526:1999/Commission Internationale de L'Eclairage (International Commission on Illumination [CIE]) S005/E-1998, *CIE Standard Illuminants for Colorimetry* (*CIE standard illuminant D65*)

- CIE 15:2004, *Technical Report: Colorimetry*

Tests, Procedures and Equipment

Using a colorimeter verify the color, gamut, chromaticity, gamma, display brightness and white point, according to the project documentation. The test procedure shall follow the specific procedure and guideline as per the test equipment instructions.

Notes on Reporting

Record the precalibrated state of all tested items and document the settings achieved.

VP-107 Multiple Resolution Performance of Video Displays

Verify that the system(s) accurately displays all resolutions required by project documentation on all displays within the system (i.e., no pixel shift, no geometric distortion, no artifacts from scaling, letterboxing, pillarboxing, or windowboxing).

Introduction

In modern AV solutions, it is commonplace for the system to switch between multiple input sources of varying display resolutions. The system displays must be carefully considered to ensure the output of the display is capable of recreating the required resolutions.

When displays are not capable of presenting resolutions in their native format, a scaler may be necessary to process the resolution to a level the output display can accept. This process should provide an output with no artifacts or distortion. While many displays now have internal scaling, external scalers usually provide a wider range and higher performance.

One of the primary considerations when selecting displays is the display resolutions of the intended input devices. A list of input devices and their preferred (or capable) resolutions should be contained in the project documentation. If such a list is not found in the documentation, the contractor should determine the expected types of input resolutions.

While it will not be possible to select a display that will show every resolution in the native format, it is important not to limit the system with a display that is incapable of showing the higher resolutions required. Therefore, the display should be selected based on the highest resolution the system is expected to display. It is also prudent to consider future technology trends to provide a system that will ensure optimum performance over longer periods.

Reference material includes Extron's:

- *The ABCs of Digital Video Signals*

- *Understanding EDID—Extended Display Identification Data*

- *Scalers: Set Up and Optimization* (white paper)

Tests, Procedures, and Equipment

While it is possible and preferred to use the actual input devices to test a system, at times a signal test generator may speed up the testing process. Signal test generators also include test patterns that provide more discerning images for evaluation. Testing should include a review of all input possibilities to all output displays.

Sample test products include Extron RGB 300 or 400 VTG.

Table 6 Typical scan rates (Courtesy of Extron)

PC/Laptop Rates						
Name	Resolution	Horizontal (kHz)	Vertical (Hz)	Aspect Ratio	Active Horizontal Pixels	Active Vertical Lines
VGA	640×480	31.47	60	4:3	640	480
SVGA/VESA5	800×600	37.88	60	4:3	800	600
XGA/VESA3	1024×768	48.36	60	4:3	1024	768
720p PC	1280x720	44.77	60	16:9	1280	720

WXGA3	1280×768	47.77	60	15:9	1280	768
WXGA2	1280×768	47.99	60	15:9	1280	768
WXGA4	1280×800	49.70	60	16:10	1280	800
SXGA/VESA11	1280×1024	63.98	60	5:4	1280	1024
WXGA6	1360×768	47.72	60	16:9	1360	768
WXGA7	1365×768	47.69	60	16:9	1365	768
WXGA8	1366×768	47.78	60	16:9	1366	768
SXGA+2	1400×1050	65.32	60	4:3	1400	1050
WSXGA	1440×900	55.94	60	16:10	1440	900
UXGA/VESA13	1600×1200	75	60	4:3	1600	1200
WSXGA+1	1680×1050	64.67	60	16:10	1680	1050
WSXGA+2	1680×1050	65.29	60	16:10	1680	1050
1080p PC	1920×1080	67.16	60	16:9	1920	1080
WUXGA1	1920×1200	74.04	60	16:10	1920	1200
WUXGA2	1920×1200	74.56	60	16:10	1920	1200

HDTV Rates

Name	Horizontal (kHz)	Vertical (Hz)	Aspect Ratio	Active Horizontal Pixels	Active Vertical Lines
NTSC 480i	15.73	59.94	4:3	720	485/242.5
PAL 576i	15.625	50.00	4:3	720	576/288
EDTV—480p	31.47	59.94	4:3	720	480
EDTV—576p	31.25	50.00	4:3	720	576
HDTV—720p	37.5	50.00	16:9	1280	720
HDTV—720p	44.96	59.94	16:9	1280	720
HDTV—720p	45.00	60	16:9	1280	720
HDTV—1080i	28.125	50.00	16:9	1920	1080/540
HDTV—1080i	33.72	59.94	16:9	1920	1080/540
HDTV—1080p	27.00	24.00	16:9	1920	1080
HDTV—1080p	56.25	50.00	16:9	1920	1080
HDTV—1080p	67.43	59.94	16:9	1920	1080
HDTV—1080p	67.50	60	16:9	1920	1080
2K 2048×1080	67.43	59.94	1.90:1.	2048	1080

Table 7 4K rates

4K Rates

Name	Resolution	Aspect Ratio	Pixels
Ultra High Definition Television	3840×2160	1.78:1 (16:9)	8,294.400
Ultra Wide Television	5120×2160	2.37:1 (21:9)	11,059,200
WHXGA	5120×3200	1.60:1 (16:10, 8:5)	16,384,000
DCI 4K (native resolution)	4096×2160	1.90: 1 (19:10)	8,847,360
DCI 4K (CinemaScope cropped)	4096×1716	2.39:1	7,028,736
DCI 4K (flat cropped	3996×2160	1.85:1	8,631,360

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. Notes should indicate which resolutions failed and on which displays.

VP-108 Projected Display Brightness Uniformity

Verify that the combined installation of projector and screen provides a display to the viewer that meets the requirements of the project documentation. This verification item shall require a metric to be verified.

Introduction

This item verifies that the brightness of the image is uniform across the full screen area. The purpose is to show that the projector and screen as a combined system show no hot spots or other irregularities in the brightness.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	ISO/CIE 10527–1991 (CIE S002-1986), *CIE colorimetric observers*.
5. Manufacturer Documentation	
6. Other Best Practice Documentation	Jeffreys, Greg. 2006. *Specifying and Assessing Projected Image Quality.*

Metric Selection

The metric is based on information and testing performed and documented in *Specifying and Assessing Projected Image Quality* (2006):

- 90% uniformity is good
- 85% is acceptable
- 80% is the low threshold of acceptability
- Below 80% is not acceptable

Tests, Procedures, and Equipment

After the projector has warmed up for at least 30 minutes, show a fully white image on the screen. Use a photometer to measure the luminance level of the screen in the center of nine locations on the screen. The nine locations are created from dividing the image area into a 3×3 grid of equally-sized areas. The measurement should be taken on the center axis of the screen and at a distance of at least three times the width of the screen.

1	2	3
4	5	6
7	8	9

To calculate the uniformity percentage:

Uniformity Percentage = ((((L1 + L2 + L3 + L4 + L6 + L7 + L8 + L9) / 8) / L5) * 100)

Where L is luminance level for each location.

1. Add the recorded luminance value for all areas except the center area.

2. Divide the total by 8.

3. Divide the calculated average by the luminance value of the center area.

4. Multiply by 100 to achieve the uniformity percentage.

The test device shall be a photometer (e.g., a luminance meter or spot photometer with up-to-date calibration) with spectral luminance response of the standard observer with photopic vision as defined in CIE S002. The acceptance angle of the meter shall be 2 degrees or less.

Notes on Reporting

Provide a worksheet document showing the recorded values for each of the nine areas. The worksheet shall also show the calculations to achieve the final uniformity percentage.

VP-109 Projected Image Contrast Ratio

Verify that the system conforms to the appropriate viewing category as defined in the project documentation. The testing methodology in ANSI/INFOCOMM 3M-2011 shall be used. The projected image contrast ratio shall be measured for all projected images within the system.

Introduction

This item covers the capability of a video projection system to meet a specific contrast ratio based on the intended viewing requirements. This verification is based on ANSI/INFOCOMM 3M-2011. Contrast ratio is one of the fundamental factors for a projection system to produce a pleasing viewing experience. The verification measures the luminance of black and white blocks on the screen to calculate the difference between the two, which is expressed as a ratio.

As specified in the Standard, this verification tests the projection system, not the capabilities of a particular piece of hardware to achieve a specified contrast ratio.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	ANSI/INFOCOMM 3M-2011, *Projected Image System Contrast Ratio.*
4. Other Standards	
5. Manufacturer Documentation	
6. Other Best Practice Documentation	

Metric Selection

There are four viewing requirement categories listed in the Standard:

- Passive viewing (7:1)
- Basic decision making (15:1)
- Analytical decision making (50:1)
- Full motion video (80:1)

Tests, Procedures, and Equipment

Detailed instructions and equipment needed for conforming to ANSI/INFOCOMM 3M-2011 are included in the standard, which can be downloaded from InfoComm International at infocomm.org/standards.

An alternate test is to download the HTML-based test pattern from http://docdev.infocomm.org/apps/group_public/documents.php. This set of test patterns allows for a test of the contrast ratio using only a laptop connection to the system under test. In displaying the pattern, if the chips are in the center of the image and the text is visible, the corresponding pattern represents a contrast ratio—chip 1 = 80:1, chip 2 = 50:1, chip 3 = 15:1, and chip 6 = 7:1. The chip shall be visible from all five of the referenced seating positions.

Notes on Reporting

The Standard requires a plan layout of the room and a worksheet containing measurements. Refer to the Standard for more information.

VP-110 Test Video Routes

Verify that all video routes are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and routing required by the project documentation.

Introduction

This item covers the testing of all video paths to ensure they are passing video from one point to the next. It verifies that wire numbers are correct and that there are no transposed wires from one location to another.

This test ideally should be performed at the same time as VP-100 EDID Management Plan and VP-101 HDCP Management Plan tests.

Tests, Procedures, and Equipment

Provide a test signal or source at each input location and verify that the signal is present at the output of the associated wire. A spreadsheet noting each cable with cable number should be used to track that each cable is tested.

A video test generator or laptop may be used to verify that the image is present at every output display. This test shall be repeated for every input to every output.

Notes on Reporting

Provide a spreadsheet identifying each cable identified and confirming whether they have passed the test.

VP-111 Video Camera Image and Operation

Verify that cameras, lenses, and pan/tilt systems operate as defined in the project documentation. Inspect the camera image through the full lens operation.

Introduction

Refer to the project documentation for mounting and operational requirements. The intent of this test is to ensure that the camera, lens, and pan-tilt-zoom (PTZ) assembly operate in a consistent and uniform fashion within the intended image frame area(s).

This test is especially important when a separate camera and PTZ head assembly is integrated and cabling is routed externally as cables can be easily pinched or caught within the assembly, if not harnessed correctly.

Tests, Procedures and Equipment

Visually inspect the installed equipment ensuring that the camera assembly is mounted and all cabling is harnessed to avoid mechanical obstruction within the limits of the device movement area.

Ensure that pan and tilt limits have been set and that the assembly cannot accidentally come in contact with any known movement obstructions (e.g., walls or ceiling elements). Move the camera through the entire pan-and-tilt range to ensure smooth operation.

Ensure that zoom and focus functions operate throughout the full range of the lens and that the back focus (if applicable) is properly adjusted.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

Audio/Video System Performance

Verification Items within this category verify linked audio and video system elements that cannot be separated due to their functional requirements. These items verify performance, stability, and conformance to requirements provided within project documentation. Guidance is provided on all verification items listed in the Standard, which includes linked audio and video system elements.

AVP-100 Emergency Communications

Verify that emergency communications systems properly receive inputs and information from other systems (including but not limited to life safety systems, security systems, and weather notifications), deliver appropriate notifications to target audiences, comply with regulatory requirements, and adhere to requirements defined in the project documentation.

Introduction

Audio and video systems are often required to work in conjunction with life safety systems or are part of a larger life safety system. It is vitally important to verify that any communications to and from the AV system is functional. Local codes and laws may impact or govern both the implementation and the reporting process. As a result, a comprehensive explanation of every possible test or situation cannot be covered here. For instance, some designs or local codes may only require that an audio system enter a muted state during a fire emergency. Other codes may require a complete shutdown of the audio equipment.

Tests, Procedures, and Equipment

Reference any specific tests called out in the project documentation. Also reference any specific codes or laws pertaining to the AV system's function in relation to or as part of a life safety system. List each life safety system that is interacting with the AV system. List each situational process, the expected result, and note if it passed. This may be, "Fire Alarm (Trigger), Audio system enters a muted state (Action), Passed."

Notes on Reporting

Provide a spreadsheet showing each location, the situational process, the expected result, and whether it passed or failed.

AVP-101 Genlocking (Video Synchronization)

Verify that the video synchronization of the system is performing as defined in the project documentation.

Introduction

Achieving video phase synchronization is very important when combining camera or other video signals within a video mixing or switching environment. Most devices synchronize their vertical frames with the peak of the A/C power frequency supplying them; however, when multiple devices and sources are involved, this method is not dependable enough to provide a predictable mix effect or switch.

Genlock provides a reference to where all sources are then timed to one source within a facility. With all video sources in sync with each other, time-based transitions are more accurate, with fewer artifacts such as roll, jump, and shift.

It is a good rule of thumb to avoid using loop-through connections for black burst or digital sync signals. Each timed piece of equipment should be connected to its own dedicated distribution amplifier output.

Tests, Procedures, and Equipment

Analog Video

The following inputs to the test are recommended for setting the video synchronization (timing) within an analog video environment:

1. Ensure the equipment can be timed. Some equipment may only be timed using certain outputs, and not on all available outputs.

2. Ensure the equipment has some provision for the adjustment of timing, whether it is a single control for adjusting both H-timing and SC-phase or separate controls for adjusting each.

3. For any devices that are not capable of accepting external sync, a time base correctors (TBC) would be used to provide both timing and color correction as required for items (e.g., consumer VTRs or cameras).

4. Refer to the service/application manual for the video switch/special effects generator for instructions regarding specific sync input requirements and processor settings for calibration.

Refer to the following documentation for calibration and testing:

- "Setting Up A Genlocked Studio" by Tektronix
- NTSC, PAL, and SECAM standards

Digital Video (SDI, HD-SDI, 3G-HD-SDI)

Analog sync or digital sync signals may be used within a digital studio for synchronization simultaneously depending on the specific equipment requirements.

Analog and digital reference sync signals are not replicated within the digital environment but used only for synchronization purposes. Synchronization is achieved by using specific code-word sequences representing the start of active video (SAV) and ending with a code-word sequence representing the end of active video (EAV).

There are several methods for timing between video sources to include the waveform method, the Tektronix Lightning display method, and the bowtie method.

The following test inputs are an example for setting the timing within a digital studio environment:

1. Ensure the equipment can be timed. Some equipment may only be timed using certain outputs, and not on all available outputs.

2. For devices that do not have sync reference inputs that need to be connected and timed, a digital frame synchronizer would be used to provide both timing and color correction as required.

3. Many special effects generators contain digital frame synchronizers on all or some of their inputs. If the SEG contains a digital frame synchronizer internal to the device, adjustments are minimal.

4. Refer to the service/application manual for the video switch/special effects generator for instructions regarding specific sync input requirements and calibration procedures.

5. For SDI video with embedded audio (ANSI/SMPTE standard 272M), it is important to ensure that audio is in time with the video stream. A waveform rasterizer provides measurements for both video and audio data streams.

Refer to the following documentation for calibration and testing:

- "Digital Video Measurements" by Tektronix

- SMPTE 318, SMPTE 259M, SMPTE 344M, SMPTE 292M, SMPTE 372M, and SMPTE 424M standards

Also see "Timing and Synchronization in a Multi-Standard, Multi-Format Facility" by Tektronix.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

AVP-102 Audio and Video Recording

Verify that audio and video signals are being routed to the recording device(s) and that the recording device(s) is operating correctly, as defined in the project documentation.

Introduction

This item covers the testing of recording devices (audio and video).

Tests, Procedures, and Equipment

Provide source material to the system under test (audio and video, as necessary). Use the installed recording equipment to capture a sample of the source material. Evaluate the recorded material based on the following criteria as pass/fail.

For audio, ensure that:

- It's free from distortion.

- Assuming the audio system gain structure is correct, a unity gain level from the mixing or source device produces unity gain at the recording device.

- The channel separation is correct (left and right channels are correct).

For video, ensure that:

- The aspect ratio is correct.

- The frame rate, compression, or other codec-related factors are optimized as per the specification.

- Audio and video are properly synchronized.

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale

Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

Where issues are detected, it is recommended that a second level of testing is employed using specialist protocol analyzers to look at bit error rates, packet loss, and processing and timing issues. Networks should also be reviewed for their impact as part of the related verification item IT-100 Content Delivery Network.

Given the costly and specialized nature of the test equipment for the second-level testing, hire the equipment or a testing service provider who is skilled in the hardware platform and test equipment.

Notes on Reporting

Provide a sample audio or video recording with the project documentation.

AVP-103 Audio/Video Sync

Verify that audio/video synchronization is maintained to ensure the proper time alignment of signals during playback at the point of user experience or transmission as defined in the project documentation. This verification item should require a metric to be verified.

Introduction

In many AV systems, audio and video signals may take very different paths to get from the source to the point at which the user will experience them, whether that point is a seat within a local venue, a remote location, or following the distribution of a recording.

Audio and video signals may also undergo very different amounts of processing, each with their own inherent delay.

Systems in which associated audio and video signals are transported or processed separately, and subsequently combined for transmission or display, carry a potential for one of the signals to be delayed more than another, creating synchronization errors. These errors are typically corrected by applying delay to the advanced (least delayed) signal, such that it aligns with the most delayed signal.

To ensure good usability, it is important that the signals arrive in synchronization at the point where the user will experience them, regardless of whether that point is local or remote.

This item requires verification that the audio/video synchronization is within acceptable limits.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	ITU-R BT.1359.1, *Interface for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601.*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	EBU Recommendation R37, *The relative timing of the sound and vision components of a television signal.* ATSC IS-191, *Relative Timing of Sound and Vision for Broadcast Operations.*

Metric Selection

In the absence of defined requirements in the project documentation, the recommended maximum error whereby the audio should lead the video is +40 ms and whereby the audio should lag behind the video is –60 ms throughout an entire signal chain. These equal to two or three frames on 50 Hz-video systems.

For television applications, the recommended maximum synchronization error is +15/–45 ms. A positive number indicates that the audio is in advance of the video.

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Tests, Procedures, and Equipment

A *blip-and-flash* test is a common method for measuring the synchronization of audio and video. A test signal consisting of one full frame of white video, accompanied by the same time length of audio tone, is required. An alternative signal may be an image changing from full-frame white to full-frame black at regular intervals, with each change accompanied by a brief click or tone burst. This can be generated by a laptop running a slideshow.

The signal at the point of reception can then be analyzed using a dual-channel digital storage oscilloscope to record the timings at which the audio and video signals are received.

If a metric is not being measured, then a subjective reception test using the same test signal may be used, in addition to a replay of video material that depicts a person speaking (e.g., a newsreader). The subjective effect of any delay can then be reviewed for a pass/fail assessment.

Tests should be undertaken at the inputs of recording devices, the inputs to transmission devices (e.g., VC codecs, broadcast circuits), and locally within the presentation space at both near-screen and farthest-viewer positions.

Notes on Reporting

Provide a record of measurements.

AVP-104 Radio Frequency Television Distribution

Verify that the radio frequency and satellite intermediate frequency distribution systems provide all services to all endpoints as defined in the project documentation. This verification item shall require a metric to be verified.

Introduction

Verify that the ultra-high frequency radio signal (UHF) and satellite intermediate frequency distribution system adequately perform to provide analog and/or digital television and radio services. The correct RF signal level and quality should be verified at system outlets for direct connection to the AV systems for display devices with integrated tuner/decoders, end-point decoders, and Internet Protocol television (IPTV) encoders in accordance with the project documentation and industry standards. This requirement applies equally to feeds provided locally at display positions and also for rack-mounted equipment as part of a headend or similar system.

Signal-level measurements should account for the rain fade margin (for satellite systems) and distribution system degradation. Perform satellite testing over a period of heavy rain as well as non-cloudy conditions. Verification should be avoided during periods of high solar-flare activity, which will affect or black out satellite reception.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	AS/NZS 1367:2007, *Coaxial cable and optical fibre systems for the RF distribution of analog and digital television and sound signals in single and multiple dwelling installations.* BS EN 60728, *Cable networks for television signals, sound signals and interactive services.*
5. Manufacturer Documentation	
6. Other Best Practice Documentation	Calaz, R.A. 2009. *Digital TV, Satellite and Multimedia*.

Metric Selection

Metrics will be sourced from the national broadcast, cable, and/or satellite standard for the system to be installed. This varies from country to country and, in some cases, region to region.

Tests, Procedures, and Equipment

Free-to-air analog, free-to-air digital, pay television satellite dish or cable connection, and coaxial and/or optical fiber distribution systems should be installed prior to testing.

Testing should be carried out at each outlet individually, with the system operating with all outlets connected (i.e., at full operational load).

A simple signal level meter that is calibrated in dBµV is sufficient for basic level tests. A more advanced analyzer such as Sencore SLM 1475 or Schomandl SM120 may be necessary for carrier-to-noise (C/N) ratio and bit error rate (BER) measurements.

Test against the following parameters:

- Signal levels within the stated range—Excessively high signal levels may overload receiver input stages.

- Signal/noise (S/N) ratio (C/N ratio)—Higher signal levels are better and they must meet minimum required levels.

- Bit-error rate (digital signals)—Lower signal levels are better and they must not exceed maximum required level.

Notes on Reporting

The results of the measurements at each outlet should be recorded and verified against the determined metrics, and a pass/fail result should be recorded for each.

AVP-105 Source Testing

Verify that the signal produced by a source typical of what will be used in normal operation of the system is routed through the system to applicable endpoints and produces the performance as defined in the project documentation. A test generator shall not be used for this verification item.

Introduction

It is important to verify that the system functions with the equipment that the owner intends to use with the system. This specifically applies to owner-furnished computers, laptops, tablets, and so on. While a system may pass tests using a video test generator set to various expected resolutions, an owner-provided laptop may handle EDID, HDCP, or resolutions differently than expected.

Consider that, though not as varied as laptops or other bring-your-own-devices (BYODs), DVD, Blu-ray, or file-based media may not play as expected due to authoring issues or settings in the playback devices that are only active with certain content.

While it would be impossible to test a laptop input for every possible laptop and resolution that may come into the room, the system needs to be tested with the predominantly issued laptops at the owner's facility. If the facility is all PC based, test the system using a non-PC laptop as well, and vice versa.

Tests, Procedures, and Equipment

Play media in source devices of multiple different formats and resolutions. Verify that the playback of the devices performs as noted in the project documentation (e.g., resolution, scaling, aspect).

For fixed PCs provided by the owner, verify the resolution settings, aspect ratios, and scaling.

For guest laptop inputs, request from the owner a representative laptop (and possibly tablet device) to test the system inputs. Test the laptop at the native resolution in a cloned desktop mode, and in an extended desktop mode.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

Cable Management, Termination, and Labeling

Verification items within this category verify the workmanship for installation and management of all systems' cabling, labels, and connections conformance to requirements provided within project documentation. Guidance is provided on all verification items listed in the Standard, which includes site cabling, rack cabling, furniture cabling, and loose cables.

In this context, "cable" refers to all cabling including fiber and copper (e.g., twisted pair, multicore, coaxial).

CABL-100 Cable Bend Radius

Verify that cables are not bent beyond their minimum bend radius as specified in cable data sheet in order to maintain signal integrity as defined in the project documentation. Project documentation may state a larger radius to allow for a safety margin.

Introduction

The bend radius is the "maximum radius that a cable can be bent to avoid physical or electrical damage or cause adverse transmission performance," per BICSI's *Information Transport Systems Installation Methods Manual*.

The only acceptable method to determine the acceptable minimum bend radius is to reference the cable manufacturer's requirements as stated in the cable data sheet.

NOTE Avoid rules of thumb. As the signal requirements on cables change, so do the handling and installation requirements, including bend radius. Older rules of thumb for bend radius are not applicable, and manufacturers' requirements should be followed. When such information cannot be found, look at the cable spool's center spindle to determine the minimum radius acceptable.

Refer to the following documentation:

- TIA-569-C, *Commercial Building Standard for Telecommunications Pathways, and Spaces*/AS/NZS 3084, *Telecommunications installations—Telecommunications pathways and spaces for commercial buildings*/EN 50174-2:2009, *Information technology—Cabling installation—Part 2: Installation planning and practices inside buildings*

- NFPA 70®, *National Electrical Code®*, AS/NZS 3000, *Electrical installations* (known as the Australian/New Zealand Wiring Rules), IET Wiring Regulations (BS 7671)

- Cable manufacturer specifications

- BICSI *Information Transport Systems Installation Methods Manual* and BICSI/InfoComm *Audiovisual Design Reference Manual*

Particular attention should be paid to the following problem areas:

- Racks—The cable routing inside racks requires making turns and performing various other manipulations of individual cables and cable bundles. Without preplanning the equipment locations and considering the various cable routes, anchoring, and termination points, the installer can unknowingly surpass the minimum bend radius of cables.

- Pull/junction boxes in conduit runs—Improper placement of conduit terminations into pull-boxes throughout various conduit routes and improper sizing of pull-boxes can force the installer to surpass the minimum bend radius of the cable. For pull-boxes with multiple conduit terminations, the minimum bend radius of the cable within the pull-box can be surpassed by not allowing enough room to transition from one conduit to an adjacent conduit.

- Connection plates and back-boxes don't have enough room for installing cables with connectors, causing kinks. The installer should consider right-angle connectors wherever possible to help alleviate this problem.

- Raceways/skirting duct and furniture routing—Perimeter raceways of various transition fittings should be sized to accommodate the minimum bend radius of the cable(s) being installed.

Tests, Procedures, and Equipment

Visually verify cables for the minimum bend radius and record them as pass/fail.

Notes on Reporting

For any standard that is discovered during research, give the following minimum requested information:

- Standard name

- Standard number

- Author/association

- Abstract

- Keywords

- Application text

- Stakeholders

- Project types

- Document access link

- Date

- Cost

CABL-101 AV Connector Plate Input and Output Labeling

Verify all AV connector plate input and output labeling as defined in the project documentation.

Introduction

This item covers ensuring that all system input and output plates carry the correct labeling, both in terms of type of labels and accuracy of information. This applies to all input plates that may be used in a system (e.g., in floor boxes, wall boxes, desk panels, rack panels). It does not cover patch panels (see item CABL-112 Patch Panel Labeling).

Tests, Procedures, and Equipment

This item should include both a physical inspection of all panel labels and verification that the label information is accurate in the context of the system function, as indicated on the drawings.

The physical assessment should ensure that the labeling is the correct type and durability as required by the project documentation and that it meets good practice. Appropriate labeling could be direct panel engraving, applied engraved labels, machine printed labels, or similar. Text should be typewritten, never handwritten, and the labeling should be durable and not easily removable. Text color should provide good contrast to the background color, and the text size should not be too small or too large such that sufficient information can fit the available space.

Labeling accuracy should be verified by checking the connector function in the system design. For example, if an input is labeled PC 1, then pressing PC 1 on the control panel should activate that input.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard; however, a detailed record of the inspected panels, physical verification of the information listed on the labels, and the accuracy of the information listed by connector provides for a complete and correct verification of this item.

CABL-102 AV Connector Seating

Verify that all AV connectors are correctly keyed, seated, and latched to respective connection points as defined in the project documentation. Conditions where physical parameters exceed the connector's ability to maintain full seating should be resolved as defined in the project documentation.

Introduction

This item relates to inspection of all the AV connectors to verify that they are appropriately seated and latched.

Refer to InfoComm *AV Installation Handbook, Second Edition*, and InfoComm installation courses. Follow the recommended manufacturer termination techniques.

In situations where certain connector types are not maintaining a full engagement (i.e., gravity against a non-latching connector), implement an alternative installation method should be implemented.

Tests, Procedures, and Equipment

Tests

Visual inspection of the connectors is required. The inspection should ensure that all connectors are fully and squarely mated, and that all locking mechanisms, clamps, latches, and lock screws are fully tightened/engaged.

Procedures

Visually inspect that the AV connectors are making full engagement.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-103 AV Connector Verification

Verify that all cable terminations are made securely and meet the recommendations of the connector and cable manufacturer, published standards, as well as the requirements defined in the project documentation.

Introduction

This item relates to inspection of all the AV connectors to verify that they are appropriately terminated.

Tests, Procedures, and Equipment

Visual inspection of the connectors is required. Termination connectors shall be inspected for workmanship, physical integrity, and appropriate preparation of wire conductors or optical fibers. The inspection may require partial disassembly or removal of connector covers or shells.

All connectors shall be clean and free of any dirt or debris. All terminated cables shall be supported and dressed in accordance with the project specifications, including the use of appropriate wire management products (e.g., heat shrink, split loom, wire ties, Velcro ties, tape).

Refer to InfoComm CTS-I documentation, cable termination best practices, and connector/cable manufacturers' termination schemes.

Follow project documentation if there is a possibility of using more than one connector type.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-104 AV Power Cable Management

Verify that all AV equipment power cables are managed as defined in the project documentation. Verify that cables are managed in a uniform and acceptable manner so as not to compromise safety/OEM warranty, AV signal quality, and/or future field service.

Introduction

This item is intended to ensure correct management of power cabling within AV equipment racks, control desks, credenzas, joinery, and millwork. It is important to ensure separation between the mains cabling and AV cabling to minimize interference. Management of power cabling is also important for safety reasons.

Tests, Procedures, and Equipment

Check to make sure that there is adequate separation between power cables (110–230 V) and AV cables. Verify that power cables are routed in a manner that allows devices and power supply transformers to be serviced. When devices have permanently attached power cables, ensure that the power cables are fastened with a reusable cable tie or hook and loop.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-105 AV System Cable Labeling

Verify that all cables are identified by a unique ID as defined in the project documentation. Verify that this unique ID is displayed permanently at both ends of the cable, is legible, and is positioned where it can be seen without undue disturbance.

Introduction

This item covers ensuring that all cable labeling throughout the AV system meets the requirements from the Standard and the system design information. This applies to all AV cabling that may be used in the AV system (e.g., video, audio, and control cable and also mains power cables that are provided as part of the AV system build, which is typically mains power cords between equipment rack distribution units and individual pieces of equipment but may include other mains power cables).

Tests, Procedures, and Equipment

First, identify the project's specified/required labeling requirements. These may be contained in the project documentation, company workmanship guides, or other best practice documentation. The project documentation will always take precedence.

The cable labeling at each end of each cable should be visually checked to ensure that it meets the requirements determined for the project. The labeling should be verified against requirements for:

- Legibility—Typewritten/machine printed labels (i.e., not handwritten, good contrast). Color coding may also be used if required.

- Durability—The label should stand the test of time without fading or suffering effects of wear (especially on flexible connecting cords).

- Accessibility/visibility—The labels should be easily readable without needing to disturb the cable loom or move other equipment.

- Accuracy—Labeling should be checked against the system drawings/cable schedules to ensure it matches and each label/identifier is unique to that cable. It may be acceptable to use the same identifier in multiple rooms/systems of the same type on a single project, but an identifier should never be duplicated within a single system.

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Notes on Reporting

A simple pass/fail is all that is required by the Standard. Labeling that does not meet the requirements of the project should be highlighted for rectification. An inspection record against the system schematics or cable schedule to show the checking of each end of each cable would provide for a more complete verification record.

CABL-106 Cable Separation

Verify that both site and rack cables have appropriate separation according to signal type and level as defined in the project documentation.

Introduction

Proper signal separation ensures minimal interference of electrical signals. Additionally, it lends itself to neatly organized racks and cable paths. When organized this way, troubleshooting, future modifications, or other service is more efficient.

Refer to the relevant national electrical code (NFPA 70®, *National Electrical Code*®, in the United States, AS/NZ 3000 in Australia/New Zealand, IET Wiring Regulations [BS 7671] in the United Kingdom) as well as IEEE Color Books and related national publications and standards for mandatory safety and separation guidelines.

Also refer to InfoComm *Elements of System Fabrication* for best practice documentation.

For projects delivered in defense environments, routing should be in accordance with the information security manual/guidelines and in compliance with the base requirements, including the Australian Defence Signals Directorate (DSD) Information Security Manual and US DoD guidelines.

Tests, Procedures, and Equipment

Visually verify the following as pass/fail:

- Cables are bundled based on different signal types.

- Cables with the greatest difference in signal level should have the farthest separation.

- At the rear of a rack, the speaker level, RF, control, power, ground, and networking cables should be bundled individually on the left. Also at the rear of the rack, the microphone level, line level, video, RGBHV, digital control code or time code, and digital video cables should be bundled on the right.

- Separation of different signal types shall be a minimum of 100 mm (4 in) within a rack.

- Separation of different signal types shall be in separate conduit or raceway, when not in the rack, or in partitioned raceway.

Notes on Reporting

To enable auditing to provide evidence of correct procedures, taking photos prior to closing walls and ceilings is recommended.

Defense projects in many countries require access hatches to enable inspection of routing and labeling as part of the national information security requirements.

CABL-107 Cable Supports

Verify that all cables are supported throughout their lengths as defined in the project documentation.

Introduction

Cable supports may include J-hooks, bridle rings, lacing bars, ladder raceways, catenary, and cable baskets. Cable supports should be placed in a manner than prevents cables from hanging or sagging in a manner that would place stress on the cable itself or terminations.

Tests, Procedures and Equipment

Check that the cable supports are placed in a manner than prevents cables from hanging or sagging to ensure they don't put stress on the cable itself or terminations.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-108 Cable Ties

Verify that, where appropriate, cable ties are used to secure the cables, are correctly tensioned, and that the correct type of cable tie is used in the project as defined in the project documentation.

Introduction

This item verifies that there are sufficient cable ties to keep cable bundles and individual cable organized and secured into place. Cable ties could be hook and loop style, nylon, plastic, or various metals.

Tests, Procedures, and Equipment

Visual inspection is all that is required to verify this item. Cable ties should be placed or staggered in a neat and orderly fashion. Ensure that excess pressure is not being placed onto the cable, causing indentation or deformation. When cutting cable tie excess, ensure that no jaggies or sharp corners are left behind. When using cable bundles, size should not exceed the manufacturer's or code specifications. It is appropriate to have the cable tie length match the correctly sized cable bundle.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-109 Cables Bundled by Type

Verify that cables are only bundled together when their construction, signal type, and signal level are compatible and will not cause measureable crosstalk or interference between cables.

Introduction

Proper signal separation ensures minimal interference of electrical signals. Additionally, it lends itself to neatly organized racks and cable paths. When organized this way, troubleshooting, future modifications, or other service is more efficient.

Refer to the relevant national electrical code (NFPA 70®, *National Electrical Code*®, in the United States, AS/NZ 3000 in Australia/New Zealand, IET Wiring Regulations [BS 7671] in the United Kingdom) as well as IEEE Color Books and related national publications and standards for mandatory safety and separation guidelines.

Also refer to InfoComm *Elements of System Fabrication* for best practice documentation.

Tests, Procedures, and Equipment

Visually verify the following as pass/fail:

- Cables are bundled based on different signal types.

- Cables with the greatest difference in signal level should have the farthest separation.

- At the rear of a rack, the speaker level, RF, control, power, ground, and networking cables should be bundled individually on the left. Also at the rear of the rack, the microphone level, line level, video, RGBHV, digital control code or time code, and digital video cables should be bundled on the right.

- Separation of different signal types shall be a minimum of 100 mm (4 in) within a rack.

- Separation of different signal types shall be in a separate conduit or raceway/skirting duct, when not in the rack, or in partitioned raceway/skirting duct.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-110 Cables Dressed

Verify that cables are dressed to ensure that all rack and site cables are installed to provide serviceability, safety, and aesthetics as defined in the project documentation.

Introduction

The wiring within a rack provides critical termination points for the majority of the system. This verification item includes a visual inspection to ensure that the cabling is terminated, organized, and installed in a neat and organized way to provide long-term quality, serviceability, and usability.

Tests, Procedures, and Equipment

Visually verify the following as pass/fail:

- Cables are supported by cable management rings, stress relief loops, lacing bars, or other horizontal and vertical support structures so that the termination point does not bear the weight of the cabling.

- Cables are neatly organized into groups (see verification item CABL-106 Cable Separation).

- Cables are trimmed to length for bulk wiring, leaving only a service loop that is neatly secured in the rack.

- Verify there are no splices in the cabling.

- Premade cables are the appropriate length and secured so that non-locking connectors remain in place.

- Appropriate cable ties are used. Velcro straps are preferred. Verify that any cable/zip ties are secure but not tight to the point where the cable jacket is deformed. Cable/zip ties should not be used on optical fiber or network cabling.

- Cabling entering or exiting the rack has the appropriate jacket, sleeve, or bundling and enters or exits the rack through the appropriate opening in the rack. In the case of pullout or swinging racks, the cabling has the appropriate extra length required for the rack to move in the full range without undue tension or strain on the bundle. Within that range of movement, the bundle maintains the appropriate bend radius.

- Abrasion points are noted and addressed. Knockouts in racks have grommets or other protection for the cabling so that any rack movement will not cause cable wear over time.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-111 Patch Panel Configuration

Verify that all patch panels have been correctly wired and configured as defined in the project documentation.

Introduction

Patch panels allow for a demarcation point to exist in a signal path. Patch panels should be properly labeled, populated, normalized, and terminated according to project documentation. Labeling is covered under CABL-112 Patch Panel Labeling. This item applies to all forms of patch panel (i.e., audio, video, control, and so on).

This item may also cover data patch panels where these are provided as part of the AV system, but specific requirements for data cabling patch panels provided by a cabling contractor as part of the IT works would not be covered by this item.

Tests, Procedures, and Equipment

This item should include a physical inspection of all patch panels and verification that the wiring and configuration is accurate in the context of the system function, as indicated on the drawings.

This should include testing for:

- Polarity (phase) for audio signals
- Normalization (correct pass-through of normalized signals, which are broken according to the specified half-, full- or double-normalized) for audio signals
- Provision of U-links or jumper cables for normalizing on video or other patch panels

Notes on Reporting

Simple pass/fail is sufficient to meet the Standard. A detailed record of the panel testing (e.g., by marking up a copy of the relevant system schematic) would be beneficial.

CABL-112 Patch Panel Labeling

Verify that all patch panels have been labeled as defined in the project documentation. Verify that all labeling is machine-printed, consistent, durable, accurate, and legible.

Introduction

This item covers ensuring that all system patch panels carry the correct labeling, both in terms of type of labels and accuracy of information. This applies to all patch panels that may be used in a system (e.g., video patching, audio patching, control patching, power patching). It may also cover data patch panels if they are provided as part of the AV system, but specific requirements for data cabling patch panels provided by a cabling contractor as part of the IT works would not be covered by this item.

Tests, Procedures, and Equipment

This item should include both a physical inspection of all panel labels and verification that the label information is accurate in the context of the system function, as indicated on the drawings.

The physical assessment should ensure that the labeling is the correct type and durability as required by the project documents and meets good practice. Appropriate labeling could be direct panel engraving, applied engraved labels, machine printed labels strips, or similar.

Text should be typewritten, not handwritten, and the labeling should be durable and not easily removable. Text color should provide good contrast to the background color, and the text size should not be too small to read (no more than two lines of text) or too large such that sufficient information cannot be provided in the space available. Label pitch must match the pitch of the patch panel connectors and the label should be held in place so that it cannot slide off easily.

Labeling accuracy should be verified by checking the connector function in the system design (e.g., a patch connection labeled mixer input 1 should connect to the corresponding mixer input).

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. A detailed record that verifies the accuracy of the patch panel labeling should be developed through system testing (e.g., by marking up a copy of the relevant system schematic).

CABL-113 Termination Stress

Verify that all cable terminations have been completed and adequately supported so as to minimize stress on the termination point and/or connector.

Introduction

This item verifies that cable terminations are not subject to excessive stress that may lead to failure. Heat shrink, springs, clamp style (properly tensioned), cable support, and correct cable forming, are examples of ways to reduces stress on cable terminations.

Tests, Procedures, and Equipment

Ensure that there is a sufficient amount of cable strain relief included to prevent deterioration of proper terminations.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-114 AV Connector Plate Consistent Labeling

Verify that AV connector plates have consistent labeling throughout the project as defined in the project documentation.

Introduction

This item ensures that all labeling throughout the system is consistent as a whole and with the system design information. This applies to all connection plates that may be used in a system (e.g., in floor boxes, wall boxes, desk panels, rack panels, and patch panels).

Tests, Procedures, and Equipment

The label text on all panels and connectors in the system should be inspected and checked against all other items that are relevant to that label. It should be consistent with the system schematic drawings, the panel layout drawings, patch panels, functional descriptions, and control functions (e.g., if you press the button labeled camera 1, then the camera connected to the panel labeled camera 1 should activate).

Labels on link cabling should be consistent, although this may not be identical if a designated direction of signal travel is required (e.g., a link cable between room 1 and room 2 may say "To room 2" at one end and "From room 1" at the other).

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. Inconsistencies should be highlighted for rectification, along with a recommendation as to which element should change to correct the inconsistency (e.g., the drawing, the panel label, patch panel label).

CABL-115 AV System Cabling Verification

Verify that all cabling is of the correct type and routed correctly from point to point as defined in the project documentation.

Introduction

Follow and verify the system cabling is in conformance with the project documentation. Installed cables should follow identified cable pathways and be the correct type. Check that the following items are in accordance with the project documentation or per manufacturer recommendations:

- Audio cabling type
- Video cable specifications/type (coaxial/digital cable used)
- Control cabling type
- Loudspeaker cabling type/size
- Shielding
- Optical fiber cabling type and termination
- Twisted-pair cabling (shielded twisted-pair where required)
- Cable routing and distance meets manufacturer specifications

Tests, Procedures, and Equipment

Perform visual inspection of cable types and routings. It is considered good practice to complete additional performance testing based on type, especially when high demands are placed on a particular cable (e.g., HDBaseT). Performance testing is also recommended for optical fiber links.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CABL-116 Cable Length Required for Serviceability

Verify that sufficient cabling is available so the device can be placed in a serviceable location as defined in the project documentation.

Introduction

Check that the cable length allows equipment to be easily removed and serviced and terminations to be redone. The cable bundles should also be routed and sized in a way that allows servicers to easily move equipment racks and devices without exceeding the cables bend radius.

Tests, Procedures, and Equipment

Visually inspect the cabling to ensure that moving and removing the equipment allows for easy access and does not disturb other rack components. If disconnection is required, ensure that the equipment can be moved sufficiently to allow visual identification of the disconnection point.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

Control Performance

Verification items within this category verify the control system's performance, usability, stability, and conformance to requirements provided within project documentation. Project-specific verification items that address system communications, interface and control devices, mobile device integration, external system integration (e.g., life safety, security, environmental), automated system functions, and user interface operations shall be listed in this section.

CON-100 Control System Communications

Verify that all control communications are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and functionality as defined in the project documentation.

Introduction

AV control system functionality is critical to the operation of the system as a whole since the control system communicates with each device but often monitors communications between devices and or subsystems.

Tests, Procedures, and Equipment

Identify all control paths and functions as defined in the project documentation. Monitor communications between the touchpanel and the processor, between all control devices, and from each networked device.

While monitoring, activate control functions associated with the monitored link and ensure that the data transfer is correct and the desired function(s) occur.

Equipment should include a laptop or desktop computer with appropriate software.

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Notes on Reporting

List all control paths and functions as tested.

CON-101 Control System Interfaces

Verify that AV control system interfaces to and from control systems provided by others conform to requirements as defined in the project documentation.

Introduction

As building automation systems, energy monitoring, and green building designs are deployed, AV control systems can have a primary role in smart room control monitoring and reporting by providing hardware and software interfaces with these systems as well as intuitive smart user interfaces.

Identify the inputs and functions to be tested per the project documentation. AV control system hardware has the ability to interface and control third-party interfaces (e.g., room shades, lights, screens, and building management devices). Room functions and items to be controlled and required interfaces should be noted and coordinated early in the project with final interface coordination between the AV control system programmer and the programmer/installer of the system(s) to be controlled as part of the systems integration phase.

Tests, Procedures, and Equipment

Test each interface, function, and operation for all external systems controlled by the AV control system. For example, when testing the operation of the lighting interface, check for preset changes that are corresponding to a change in the lighting level based on the selected touchpanel button function.

Notes on Reporting

List interfaces and functions tested.

CON-102 Mobile Device Integration

Verify that mobile devices that are to be supported are integrated and operating as defined in the project documentation.

Introduction

Mobile devices have become common in the AV space as control surfaces as well as collaborative bring-your-own-device (BYOD) scenarios that allow for both control and content sharing.

Tests, Procedures, and Equipment

Check the project documentation for required functionality. Ensure that the mobile device is connected to the wireless network and that selecting all commands results in the desired

action or effect. For a control example, pressing the volume button on the mobile device should ramp up the program volume in the space. For a BYOD scenario example, pressing the Share button would share video content to the selected screen or screen processor.

Review the system operation for any control dropout, where the control surface loses synchronization with the system. Where a control dropout occurs, further investigation will be required into the configuration of the device and wireless and wired network under items IT-103 Network QoS (Quality of Service), IT-114 Network Performance Under Full Functional Load, and WL-101 Wireless Control Systems Operation.

Notes on Reporting

Note as a pass/fail. Note any control dropouts and times of occurrence for further investigation.

CON-103 System Response to Emergency Condition(s)

Verify that any required response of the installed AV systems in the event of a life safety or similar emergency operates in accordance with local regulations and as defined in the project documentation. This item specifically excludes sound system response to an emergency condition, which is covered under item AP-100 Emergency Muting.

Introduction

AV systems often require connection to the fire life safety alarm system to allow for the AV systems program content to be muted upon the activation of a fire alarm. Depending on location, the authority having jurisdiction (AHJ) may require the systems to be shut down completely or allow electronic muting and/or muting the program audio and allow the fire alarm paging system to use the AV system as a supplementary system.

Tests, Procedures, and Equipment

Refer to the project documentation to confirm the required emergency actions. Initiate fire alarm activation via coordination with the fire alarm contractor or manually trigger the event simulating how the control system sees the activation. Confirm that the required action occurs when either of the two tests above is conducted.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CON-104 Control System Automated Functions

Verify that all time-dependent or automated functions executed by the control system conform to requirements as defined in project documentation

Introduction

The implementation of automated and time-dependent functions within a control system requires due diligence and specific testing to ensure that the desired event-related results are achieved via both interface and programming tasks.

Automated functions include automatic power on/off, interface with building management systems for climate control, and single-button push multi-function commands.

Tests, Procedures, and Equipment

Review the project documentation and confirm that all automated room functions are supported by the control system program and interfaces. An example would be to test the automated system power-off sequence by changing the end-of-day time to a few minutes prior to the test.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

CON-105 Control System User Interface Performance

Verify that the control system is implemented in a manner consistent with the requirements as defined in the project documentation.

Introduction

Control system installation, programming, and implementation require systematic testing to ensure that the desired function(s) are achieved via both interface(s) and custom programming code.

Review the project documentation and confirm that all of the intended room functions are supported by the control system program and user interface in a manner that provides all intended functionality.

Tests, Procedures, and Equipment

Review the project documentation and confirm that all of the intended room functions are supported by the control system program and user interface in a manner that provides all intended AV functionality.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

Verification items within this category verify that the system's project-specific record documentation has been completed. Any documentation should be delivered in electronic format wherever possible and practical. Guidance is provided on all verification items listed in the Standard, which includes drawings and specifications, test reports, manuals, and acceptance reports.

CON-106 Control System Response Time

Verify that the control system provides the user response time and maximum latency defined in the project documentation. This verification item should require a metric to be verified.

Introduction

The total latency of an AV control system is determined by several factors to include processor speed, operating system, network traffic, and data exchange requirements determined by custom code written based on project requirements. Latency should be kept to a minimum to avoid the perception that the control system is not reacting instantaneously to requests. As a rule of thumb, "please wait" or "progress popups" should be used to show in process tasks lasting more than 10 seconds.

Review the project documentation and confirm that the user interface is responsive to touch operation and does not contain latency that would lead the user to believe the system is not functioning or operating sluggishly.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	
3. InfoComm Standards	
4. Other Standards	
5. Manufacturer Documentation	
6. Other Best Practice Documentation	Nielsen, Jakob. 1993. *Usability Engineering*.

Metric Selection

Refer to these guidelines from chapter 5 of *Usability Engineering* (1993):

- **0.1 second** is about the limit for having the user feel that the system is reacting instantaneously, meaning that no special feedback is necessary except to display the result.

- **1.0 second** is about the limit for the user's flow of thought to stay uninterrupted, even though the user will notice the delay. Normally, no special feedback is necessary during delays of more than 0.1 but less than 1.0 second, but the user does lose the feeling of operating directly on the data.

- ▪ **10 seconds** is about the limit for keeping the user's attention focused on the dialogue. For longer delays, users will want to perform other tasks while waiting for the computer to finish, so they should be given feedback indicating when the computer expects to be done. Feedback during the delay is especially important if the response time is likely to be highly variable, since users will then not know what to expect.

Tests, Procedures, and Equipment

Review the project documentation and confirm that the user interface is responsive to touch operation and does not contain latency that would lead the user to believe the system is not functioning or operating sluggishly.

System and Record Documentation

Verification items within this category verify that the system's project-specific record documentation has been completed. Any documentation should be delivered in electronic format wherever possible and practical. Project-specific verification items that address drawings and specifications, test reports, manuals, and acceptance reports shall be listed in this section.

The Standard calls up the following items to be verified as pass/fail. Guidance is provided on each item.

DOC-100 Final Inventory of AV Equipment

Verify that all equipment as defined in the project documentation has been delivered.

Guidance

Verify the bill of materials from the purchase order. Verify all brand names approved for purchase, quantities of brand name items billed, and quantities shipped (make/manufacturer). Make a room/area/location/building inventory list per the project documentation. Mark deviations if the equipment quoted/approved is discontinued by the manufacturer or changed for any other reason. List all equipment as separate tables with their respective make, manufacturer, model number, description, and part codes (if required by the project documentation).

DOC-101 Approval of Samples

Verify that samples of all equipment to be used as defined in the project documentation have been submitted for approval.

Guidance

Identify the list of item samples that need to be submitted. Crosscheck the bill of materials from the purchase order with the submitted samples list. Identify who the approver is for each

sample category. Collect receipt and approval documentation (e.g., architect approval, engineering approval).

In many instances, samples may be allowed to be submitted only via a datasheet lists the required information (e.g., color, size, weight, and technical specification.)

DOC-102 Delivered Product Against Samples

Where samples of products have been required for approval, verify that the products that are delivered are the same and of the same quality.

Guidance

Crosscheck the list of approved samples with the material delivered. Verify the exact model numbers and manufacturers for the approved sample and delivered product. Confirm any special finishing required. Look for any defects in the delivered product.

DOC-103 Wireless Frequency Licensing

Verify that the correct and valid wireless frequency licensing permits have been obtained for legal operation of the system.

Guidance

This item requires that the system verifier ensure all necessary licenses and permits have been obtained for any licensable wireless systems (spectrum and/or power) that are part of the AV system. Typically, this would cover radio frequency-based microphones but could cover other systems (e.g., wireless video or communications transmission and in-ear monitor systems).

This item does not cover wireless systems that do not require a license, such as 802.11 wireless, infrared transmission systems, Digital Enhanced Cordless Telecommunications (DECT), and so on.

This verification should be carried out during the project's systems integration phase to ensure legal operation of the systems for testing purposes.

The first step is to review the project documentation and the systems design to identify all system elements that require a license. A list of the required licenses should be made.

Once identified, verify the presence of each required license by inspecting the documentation. This should include checking the validity of the dates, the licensed location, and the licensee details. Some licenses may need to be obtained directly by the client, but the system verifier should verify that all required licenses have been obtained regardless of who has obtained them.

A list of the required licenses should be provided in the operation and maintenance/as-built documentation.

DOC-104 Consultant's Testing

Verify that any consultant's testing requirements defined in the project documentation have been performed and approved.

Guidance

Specific consultant's testing requirements in addition to those identified in the Standard, should be listed and tracked early in the project.

During the post-integration phases, the consultant's testing requirements should be verified as completed and reported using the Standard's required verification reporting process and structure.

These testing requirements may include use-case and or other room-specific attributes, such as lighting and surface finishes.

Refer to appendix C for an example of functional-based testing using the system verification checklist.

Maintain a written copy of the consultant's test results from the owner or the owner's representative.

DOC-105 General Contractor's Testing

Verify that any general contractor's testing requirements defined in the project documentation have been performed and approved.

Guidance

Early in the project, the general contractor should identify and track physical installation requirements that are verified during the systems integration and post-integration phases. The general contractor should ensure that the AV system's physical infrastructure and devices are coordinated, installed, and completed.

For example, the general contractor should ensure that items such as floor boxes, screens, and projector locations are coordinated with all applicable trades working on the project.

In many instances, the general contractor will require the AV contractor to undertake specific tests as part of their contractual requirements.

DOC-106 Integrator's Testing

Verify that any integrator's testing requirements have been performed and approved as defined in the project documentation.

Guidance

The integrator's specific testing requirements, in addition to those identified in the Standard, should be listed and tracked early in the project but implemented during the systems integration and post-integration phases.

These testing requirements may include test equipment calibration or component labeling (property tags).

DOC-107 Manufacturer's Testing

Verify that any manufacturer's testing requirements defined in the project documentation have been performed and approved.

Guidance

When a manufacturer has developed their own independent testing procedures, these tests should be used in addition to integrator tests. The testing requirements should be identified and tracked early in the project but implemented during the systems integration and post-integration phases. The contractor and the manufacturer should work together to provide and utilize all necessary test equipment applicable to the installation and provide a written test for review prior to closeout/substantial/practical completion activities.

DOC-108 Owner's Testing

Verify that any owner's testing requirements defined in the project documentation have been performed and approved.

Guidance

The owner's specific testing requirements in addition to those identified in the Standard, should be listed and tracked early in the project but implemented during the systems integration and post-integration phases.

Verification items within this list are often verified via room use-case operational scenarios.

DOC-109 Third-Party Testing

Verify that any third-party testing requirements have been performed and approved as defined in the project documentation.

Guidance

Specific third-party testing requirements in addition to those identified in the Standard should be listed and tracked early in the project but implemented during the systems integration and post-integration phases.

The third-party testing entity could work with the project team, which should provide and utilize all necessary test equipment applicable to the installation as well as a copy of the team's own testing results for review during the third-party testing activities.

DOC-110 Substantial/Practical Completion

Verify that a conditional acceptance of the project has been issued by the owner or owner's representative, acknowledging that the project or a designated portion is substantially/practically complete and ready for use by the owner; however, some requirements and/or deliverables defined in the project documentation may not be complete.

Guidance

This verification item is to verify and record that the owner or the owner's representative, has issued a conditional acceptance of the project. This should be listed and tracked early in the project but implemented during the post-integration phase.

Maintain a written copy of the conditional acceptance correspondence from the owner or the owner's representative.

DOC-111 As-Built Drawings Complete

Verify that a complete set of accurate as-built drawings indicating all AV devices, AV device locations, mounting details, system wiring and cabling interconnects, and all other details has been provided as defined in the project documentation.

Guidance

As-built drawings should be submitted once the equipment installation is completed. Products should have the same labeling at the actual location and on the drawings. Separate good-for-construction drawings (with AV equipment locations matched with other services), separate as-built drawings for conduiting plans, and the actual cabling plans (interconnects) should be available. The drawings should have appropriate legends for information on mounting details, type of equipment, and so on.

Apply the drawing standards (e.g., legend title box) that comply with the consultant/client/regional format. Provide a transmittal for all drawings. Provide digital/hard copies as applicable.

DOC-112 Audio System Test Reporting

Verify that the audio system test report has been completed and issued as defined in the project documentation.

Guidance

If any particular requirement for an audio system report was detailed in the project documentation, a summary of all audio performance items should be listed.

DOC-113 Control System Test Report

Verify that the control system test report has been completed and issued as defined in the project documentation.

Guidance

This verification item is to verify and record that the owner or the owner's representative has issued an acceptance of the control system test report. This item should be listed and tracked early in the project but implemented during the closeout phase.

Maintain a written copy of the acknowledgment correspondence from the owner or the owner's representative.

DOC-114 Final Commissioning and System Turnover

Verify that the final commissioning report has been completed, issued to the proper entity, and accepted as defined in the project documentation.

Guidance

Specific commissioning testing requirements, in addition to those identified in the Standard, should be listed and tracked early in the project. Implementation of the various commissioning requirements should be carried out during the proper phases and milestones of the project.

This verification item is to confirm that the commissioning report has been completed in the manner described in the project documentation and accepted by the owner or the owner's representative. This item should be listed and tracked early in the project but implemented during the closeout phase.

Maintain a written copy of the acknowledgment correspondence from the owner or the owner's representative.

DOC-115 Required Closeout Documentation

Verify that a complete set of as-built system documentation has been provided as defined in the project documentation.

Guidance

Reference the list of closeout documentation/submittals required for completion of the project. The contractor shall then provide all required documentation to the required parties (e.g., owner, consultant). A list shall be created showing the date that an accepted submittal was approved. This verification item is considered fulfilled when all items on the list have an approval date listed.

Provide a list of all submittal items with dates received and approved.

DOC-116 Software Licensing

Verify that the usage and ownership rights have been assigned as defined in the project documentation.

Guidance

Verify that all licensing documentation including serial numbers, product numbers, or part numbers is supplied. Record a list of all products, software, and licensing details (e.g., number of seats, licensing date, and license valid date). Record the owner of the licensed software.

DOC-117 User Manuals

Verify that manufacturer's user manuals are delivered to the owner in a format defined in the project documentation (binders, PDFs, etc.) or disposed of in a responsible manner (recycling), if the owner specifies that they do not wish to receive the manuals.

Guidance

Save all the original manuals and documentation from the product packing. All the manuals should be bound as per the project documentation in binders, folders (hard copy format), or USB drives/hard-disk (digital format). If the owner does not wish to receive the manuals, they should be discarded in a proper manner, avoiding any undesirable use of documentation.

DOC-118 Video System Test Reporting

Verify that the video system test report has been completed and issued as defined in the project documentation.

Guidance

Proper video system documentation helps to identify problems or issues as they arrive. Video system test reports generally contain a pass/fail for each video source and destination. Additional information may include color space (RGB/YPbPr), test pattern, aspect ratio, resolution, and image distortions and other observed abnormalities.

Verify that the video system test report has been completed in the manner described in the project documentation and accepted by the owner or the owner's representative.

DOC-119 Warranties

Verify that all warranties are activated and that all warranty details have been passed to the owner as defined in the project documentation.

Guidance

Record the warranty details for all products in a format defined in the project documentation. All warranty documents should be signed and warranties activated with a clear note of

warranty start and end dates. Wherever applicable, extended warranty details should be highlighted.

DOC-120 Final Acceptance

Verify that a final acceptance of the project has been issued by the owner or owner's representative, acknowledging that the project is 100% complete and all required deliverables, services, verification lists, testing, verification, and signoffs have been received, and all requirements defined in the project documentation have been satisfied and completed.

Guidance

Reference the list of all final acceptance documents/submittals. Project handover documents should be signed off by all required parties (e.g., the owner, the consultant). A list with approval and signoff dates should be maintained.

Electrical

Verification items within this category verify the system's interaction with mains voltage distribution and DC power distribution within the system are in conformance with the regulatory authority and project documentation. Guidance is provided on all verification items listed in the Standard, which includes address power distribution, monitoring, and sequencing.

This category specifically excludes testing of the building's fixed electrical installation, which is deemed the responsibility of others as defined in the project documentation or by the authority having jurisdiction (AHJ).

ELEC-100 AV Equipment Connected to Proper Circuit

Verify that all AV equipment is powered from the designated power circuit and outlet as defined in the project documentation. No additional (non-AV) equipment should be connected unless permitted in the project documentation.

Introduction

Using the project documentation, verify that the outlets are properly located and connected to the designated power circuits.

Labeling the outlets with location designation and circuit information, as indicated in the project documentation, is recommended to enable system maintainers to troubleshoot the system more easily in the future.

Tests, Procedures, and Equipment

The best and most accurate method of ensuring outlets are supplied by the proper circuit is to perform a walkthrough with the electrician responsible for the installation of AV electrical

circuits. Once the outlets have been mapped to their corresponding circuits, power assignments can be confirmed.

A number of power-circuit tracers can be used with energized circuits to identify/verify outlets that are connected to a specified circuit.

NOTE Only the personnel trained in high-voltage safety procedures should use this type of test equipment. In some circumstances, requirements may state that only the designated personnel can access the circuit panels. Check with the project owner to ensure that is the case.

A simple testing may also be performed using a device that generates noise or light (radio or lamp) to verify which circuit supplies a specific outlet. This is accomplished by connecting the test device to the outlet being verified and then switching the circuit breaker(s) on or off to verify the connection.

NOTE This method may not always be acceptable, such as in cases of preexisting circuit breaker boxes, and the circuit and breaker for the AV equipment represent a new addition. Turning off the wrong breaker can cause disruption in the owner's operation.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

ELEC-101 Grounding/Earthing

Verify that all elements of the AV system are correctly bonded to an electrical ground/earth in accordance with the requirements of the regulatory authority and as defined in the project documentation.

Introduction

AV systems are susceptible to noise induced from inadequate grounding systems. Ground noise is an easy problem to create and can be an expensive problem to fix.

While there are many approaches to grounding and earthing, the priorities are:

1. A safe system

2. A system that meets the *National Electrical Code*® (NEC) and/or other electrical codes (depending on location)

3. A system that is quiet and interference free

The requirements for grounding/earthing may be different depending on the system's location. All systems must be in accordance with the local grounding/earthing requirements for safety, which are defined by the local electrical standard.

By the time a facility's ground wire reaches the AV system, it is impure and may already be carrying a significant voltage that would introduce noise into the system. Using dedicated

grounding systems for AV can greatly reduce this problem. In addition, proper grounding can increase the signal-to-noise ratio.

Noise reduction is best accomplished by reducing noise before it enters the system. Unwanted noise is picked up by several sources: interconnecting wiring, direct contact action of ground loops and common mode returns, or inductive and capacitive pick-up of nearby radiated fields. The lower the signal voltage levels in a system, the greater the susceptibility to outside interference.

Tests, Procedures, and Equipment

The following inputs should be in place prior to testing:

- Permanent power/electrical system is operational.

- Safety earthing system is fully installed back to the main earth stakes/grid/mat.

- Technical earthing system is fully installed.

First-pass testing should identify serious problems through either an audible 50/60-Hz hum or visual bars on displays. Once a problem is detected, the following actions are recommended:

- Disconnect all connections from the equipment (including power and signal lines) and reconnect the equipment and connections one by one. Stop when the hum becomes audible/visible.

- Review equipment manuals and schematics to determine how the grounding for each equipment type is configured (e.g., the difference between the signal ground and the safety earth [power outlet]). Equipment can be the source of a ground loop and, in some instances, audio or signal isolators can easily be applied and maintain the integrity of the safety earth.

- Review the cabling to determine if any incorrect wiring/termination is present (e.g., using the shield of a cable for signal).

- Review with the electrical contractor that safety earthing has been completed in accordance with the project documentation. It is best practice for all interconnected AV equipment to also be on the same electrical circuit and, therefore, the ground circuit. If the equipment is not connected in such a way, it can be temporarily connected in this manner via a power-board to determine if this is an appropriate solution.

- Perform a technical earthing review with the electrical contractor to ensure that the safety earthing has been completed in accordance with the project documentation.

- Request that an electrical contractor performs testing as part of their work, as follows:

  - Use a meter to measure the ground signal at different points in an installed system.

  - Verify that the ground level difference between system equipment is less than 1 Ω.

Notes on Reporting

Note as pass/fail. Note the ground voltage and potential.

ELEC-102 Mains Voltage Sub-Distribution Integrity

Verify that all electrical sub-distribution systems provided by the AV contractor in equipment racks, furniture, and similar structures meet local regulatory requirements for electrical integrity.

Introduction

AV contractors often provide some form of distribution of the mains voltage electrical power within the elements they build (e.g., equipment racks, control desks). This work typically includes connecting premanufactured distribution units to an incoming supply feed (e.g., a local socket outlet provided by the building electrical contractor) and connecting outlets from the units to the equipment within the rack or desk.

This item ensures that the integrity of such systems has been verified in accordance with the local requirements. This item does not cover the building's fixed electrical installation, which is the responsibility of the electrical contractor.

Tests, Procedures, and Equipment

The first step is to identify the systems to be verified and confirm the local requirements for testing. These may typically include checking insulation resistance, integrity of earthing conductors, polarity, and earth leakage.

If the distribution systems are connected to the supply via a standard mains plug, the system may be tested as an appliance using a simple portable appliance tester (e.g., manufactured by Fluke, Seaward, Kewtech, Martindale). Alternatively, skilled personnel may use test equipment for electrical circuits. To avoid damage, manufacturers' instructions must be followed and electronic equipment may need to be disconnected from the distribution system prior to testing.

Apply measurements/verification of each element as required by local codes. While this item does not require a metric, if local codes require specific measurements, they should be identified and recorded.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. A more comprehensive reporting, providing a record of the tests undertaken and any recorded values, would be beneficial.

ELEC-103 Power Sources

Verify that the sources of mains voltage AC power to be used for the supply of AV equipment are correct as defined in the project documentation and have been tested to the outlet in accordance with local electrical standards.

Introduction

This item requires that the AV contractor ensures the building electrical outlets that supply any AV equipment have the correct voltage, frequency, polarity and current rating suitable for the

AV equipment and that the outlets have been tested correctly in accordance with local requirements.

This item does not require that the AV contractor performs the actual testing of the building electrical outlets, but merely that they verify that it has been completed. This testing will usually be carried out by the building electrical contractor or client premises staff. The AV contractor should verify that this testing has been completed and the correct results have been obtained prior to connecting the AV equipment to the supply.

Tests, Procedures, and Equipment

The first step is to identify the correct power outlets to be used for connecting the AV equipment (see ELEC-100 AV Equipment Connected to Proper Circuit), and also confirm the person responsible for carrying out the outlet testing. Supply requirements as defined in the project documentation should also be identified.

The AV contractor should confirm with the person responsible for the testing that it has been carried out and that the test results match the supply requirements in the project documentation. Ideally, this will be carried out by inspection of the electrical test paperwork, but if this is not available, then written confirmation from the person responsible for carrying out the testing will suffice.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. A more comprehensive reporting, providing a record of the tests undertaken and any recorded values, would be beneficial. Copies of the electrical test documentation may be attached.

ELEC-104 Power Sequencing

Verify that the power sequencing of devices is correct as defined in the project documentation.

Introduction

This item covers testing the power sequence of devices in the system. It verifies whether the equipment turns on in the correct order and at the correct timing to maintain proper control/communication paths and to protect audio equipment from surges or power-up transients.

Consider the following questions to complete the verification process:

- If a control system is present, is it in an always-on state (constant power) so that the control processor can receive a system on command?

- Are similar equipment types grouped in logical steps of a power sequence?

- Does the sequence take into account communication between devices? For instance, in the case of EDID communication between a source, switcher, and display, are the devices powering up in an order that is most efficient for the correct EDID paths to be established?

- Are high-inrush devices like audio amplifiers switching on in such a way to avoid tripping a circuit during power-up?

- Are amplifiers on last and off first in a sequence?

Certain equipment requires constant power due to the fact that a control system can force that device into a standby or low power consumption mode. It would also need to have power so that the control system power-on command can be received by that device.

Tests, Procedures, and Equipment

When all equipment is installed and functional, power on the equipment and note any issues in the sequence. Power the system down and verify that the sequence is in the proper order (usually the reverse of power-on). Verify that equipment that needs constant power remains on.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

ELEC-105 UPS Operation

Verify that the uninterruptible power supply (UPS) is performing to the specifications as defined in the project documentation.

Introduction

Uninterruptible power supplies allow for a system to continue operation during the loss of power. A UPS will be sized to accommodate a specific power load for a specific amount of time. It is common that UPS units ship with batteries disconnected; this should be the first thing to check before performing a test on the UPS unit.

Tests, Procedures, and Equipment

Remove power/unplug the UPS unit from the power source. Devices connected to the UPS should remain powered on for the time specified in the project documentation.

Any required orderly shutdowns prior to the UPS expiry should also be checked (i.e., system server or control system shutdown).

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. Refer to the project documentation for this report.

ELEC-106 DC Power Distribution

Verify that all DC-powered devices are receiving the proper voltage and current for normal operation.

Introduction

Many pieces of AV hardware require DC power to operate. Some designs have a centralized DC power supply that provides power for multiple pieces of equipment. Even when a single power supply is used, it is important to verify that the device matches the power supply being used.

For devices that come with a DC power supply, a visual verification of the power supply may be sufficient. The visual verification of the power supply should match the voltage and current of the device. In case of problems, a full test as outlined below shall be performed.

A meter test should be conducted when a central power supply powers multiple items or when a single power supply is extended over a custom length of cable to the device.

Tests, Procedures, and Equipment

When all equipment is installed and functional, power the equipment on. Using a clamp-type ammeter (Fluke 325 or equivalent) capable of reading DC power, take a reading of the voltage and current as close to the device as possible. This is important because voltage drops occur over long power wiring. A 12-V power supply may not deliver 12 V if the cable run is long and the wire gauge is undersized for the application.

When multiple devices are being powered from a single power supply (e.g., Crestron CNPWS-75 or Extron PS124), the power supply shall be listed on the spreadsheet. Add all current readings from all devices receiving power from the single power supply. The current shall not exceed the maximum current rating of the power supply or the current-per-port specification for the power supply.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. A spreadsheet shall be made listing all DC-powered devices, the required voltage, and required current. A column for measured voltage and measured current shall also be listed.

ELEC-107 Power Loss Recovery

Verify that the AV systems resume normal operation on the restoration of power following a hard electrical power outage. Power loss recovery shall include verification of the resumption state on power recovery. Resumption state shall be the control system start-up condition/start page (where applicable) and resetting all devices to a known state as defined in the project documentation.

Introduction

This item is considered an essential aspect of delivering a modern AV system. It is considered best practice to verify this item regardless of its being specifically contained within the project documentation.

Tests, Procedures, and Equipment

Each project has specific procedures for the control of electrical power to enable the simulation of a hard electrical outage, and they shall be followed. In many countries, only a qualified electrician should perform this test to comply with the relevant safety regulations.

Lack of communication between the electrical contractor and the AV contractor has accounted for a range of failures, particularly if the AV equipment is connected prior to conducting the full suite of electrical tests. Therefore, good communication is highly recommended.

If each equipment rack has its own uninterruptible power supply (UPS), two levels of testing are recommended to be conducted as follows:

1. Switch off the mains and let the UPS run to full shutdown.

2. Simulate full interrupted power by running UPS in bypass or disconnecting and switching off the mains distribution at the electrical switchboard.

In projects where the UPS or mains is backed up by a generator, it is recommended that it is tested as well.

Upon resumption of power, verify that the AV system resets automatically to the control system start-up condition.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. Report any devices that maintain state, and do not reset to the default start condition.

ELEC-108 Power Monitoring

Verify power-monitoring equipment is working and reporting as defined in the project documentation. Power-monitoring equipment should be verified with a known electrical load where possible. If power-monitoring data is being collected for an energy management system, connectivity with the system should be verified.

Introduction

This item requires the AV contractor to ensure that any power monitoring equipment is functioning correctly and that, if data collection is in operation, the connectivity to the data system is also functioning.

A simple power monitoring system may be a mains voltage distribution unit with a power meter on the front, fitted into an equipment rack.

A more elaborate system may involve current transformers on supply wires informing meters on the rack or elsewhere, or more sophisticated distribution units with network or control data connections that provide power monitoring data to external energy management systems. The tests required will need to be tailored to suit the individual arrangements.

Tests, Procedures, and Equipment

The most basic system with a simple metering arrangement should ideally be tested by connecting a known electrical load (e.g., a load bank or fixed power heater) to the power system, and verifying that the correct value is read on the meter. If this is not possible, then an assessment of the connected load should be made by gathering manufacturers' data for connected equipment and checking that the meter reads accordingly. This method is less exact because some equipment loads will vary under different conditions (e.g., amplifiers).

If the power monitoring system is connected to an energy management or other data collecting system, then connectivity to that system should be checked. Again, a known load should be applied to the distribution system, and the remote monitoring system should be checked to see that the correct value is being reported.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. A more comprehensive reporting, providing a record of the tests undertaken and any recorded values against test loads, would be beneficial.

Information Technology

Verification items within this category verify the information technology elements of the system perform, provide stability, and conform to requirements provided within project documentation. Guidance is provided on all verification items listed in the standard which includes network integration and performance, IT systems integration, IT security, unified communications, and software licensing.

This category specifically excludes testing of the owner's information technology systems unless specified in the project documentation.

IT-100 Content Delivery Network

Verify that the content delivery network (e.g., digital signage) is in place and provides the required connectivity for the required audio, video, and control systems.

Verify that all required content licensing has been acquired.

Introduction

As more content is delivered over a shared or dedicated AV network, testing must address acceptance of the network and its ability to support the required content.

There is an expectation that the AV designer will reach an agreement with the key IT stakeholders in the design phase on the use of a shared network. It is also expected that this will be communicated to the AV contractor in the project documentation.

In many instances, an IT manager does not have the appropriate measures in place to run content on their network and/or the appropriate measures cannot be or are not adopted. This

may affect the ability to deliver content and may introduce quality issues, particularly in times of peak load. The AV contractor should be prepared to document and mutually record where this is the case and where the owner has taken this responsibility on in full knowledge of the potential reliability issues.

Such a situation can occur in some larger enterprise class networks, where making configuration changes is a more difficult global reconfiguration.

If AV systems are deployed onto a dedicated AV network for which the contractor is responsible, the IT expertise is required to deliver all aspects of the system.

The following inputs should be in place for this test:

- Shared or dedicated AV network, including wireless networks (e.g., 802.11, ZigBee, Bluetooth, DECT)

- Digital signage, media, AV inputs and IPTV content for distribution

- Digital Rights Management (DRM) servers and licenses acquired

- Conditional Access Modules (CAMs) acquired from the service provider

- Set-top boxes acquired from the service provider

- Headend installed

In many cases, the AV integrator does not install the network or the network is already in place. If the network is a responsibility of the owner/IT manager, the AV contractor should use this item to verify with the IT manager/contractor that the network is ready to distribute content. The AV contractor is expected to communicate the final configuration of all devices with the required level of IT detail to enable the network to be configured in the correct manner.

The following information, reproduced from the *AV Implementation Handbook*, is likely to be requested by an IT manager from the AV professional to run content on an IT-owned network:

- The specific location and type of data endpoints (i.e., analog or digital)

- Special patching requirements for specialized hybrid equipment (i.e., non-data use of IT infrastructure)

- Bandwidth requirements (e.g., telepresence, VTC, IPTV systems, multicast streams)

- Security concerns (FTP or telnet)

- Quality of service (QoS)

For most clients, their network standards, infrastructure, and data security needs are constantly being upgraded. There are many questions that an IT professional may pose to the AV team concerning network-enabled devices. Some initial questions coming from an IT professional might be:

- Are there static or dynamic IP devices?

- What types of content are expected to be commonly used?

- Are there VLAN implications to be considered?

- What ports need to remain open on firewalls and gatekeepers?

- ▪ Are there any devices with web-enabled user interfaces that should be password protected?

- ▪ Is there a need for protected or secure communications such as IPSec, SSH, and SSL?

- ▪ Is there a requirement for remote access to systems?

- ▪ Can networked AV devices be tested prior to installation?

- ▪ Is there a need for wireless connectivity?

- ▪ Are there requirements for VPN services?

The IT manager should be asked to confirm the following:

- ▪ Devices have been assigned their correct static/DHCP IP addresses.

- ▪ QoS is in place.

- ▪ The network is suitable for the required content and bandwidth requirement.

- ▪ The network topology is suitable for the required traffic.

- ▪ The external gateways and ports are in place for audio- and videoconference bridging.

Refer to the following verification items for further detail:

- ▪ IT-102 Network Bandwidth

- ▪ IT-103 Network QoS (Quality of Service)

- ▪ IT-104 Network Security

- ▪ IT-110 Network Topology

Tests, Procedures, and Equipment

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts manifest at or above grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale	
Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using specialist protocol analyzers to review bit error rates, packet loss, and processing and timing issues is recommended. Networks should also be reviewed for their impact as part of related verification items IT-102 Network Bandwidth, IT-103 Network QoS (Quality of Service), IT-104 Network Security, and IT-110 Network Topology.

Given the costly and specialized nature of test equipment for the second level testing, hiring the equipment or a testing service provider skilled in the hardware platform and test equipment is suggested.

Notes on Reporting

Note as pass/fail. Note any visual or audio impairment against the ITU-R BT.500-13 scale.

IT-101 IEEE 802 Wireless Security

Verify that the wireless network is protected in accordance with the client/owner's information security policies from unauthorized access and provides the required connectivity for the audio, video, and control systems.

Introduction

In many cases the, AV integrator does not install the network, so this item may need to include verification of a preexisting installation in cooperation with the IT contractor or IT manager.

The following inputs are required to test a preexisting network installation:

- Shared or dedicated AV 802 wireless network is in place with the required coverage.

- Wireless security is a vast area of expertise and covers issues such as intrusion detection, intrusion prevention, as well as authentication. Refer to *Wireless and Network Security Integration Design Guide* (CISCO, 2008) for more comprehensive treatment.

Tests, Procedures, and Equipment

Testing should verify that:

- The security scheme can be implemented with the AV equipment required to use the wireless network

- The wireless devices are compatible with the available wireless protocols

- The credentials supplied by the IT manager allow the device onto the wireless network

Notes on Reporting

Due to security issues, it is unlikely that the credentials would be documented in the operation and maintenance manuals. Security credentials may be updated on a regular basis to provide a higher level of security.

IT-102 Network Bandwidth

Verify that the required network bandwidth is available for control, audio, video, and data as part of either a shared or a dedicated AV network.

Introduction

In many cases, the AV integrator does not install the network, so this item may need to be verified by the IT contractor or IT manager if the AV systems are operating in a shared network environment.

A paper-based check should be performed in the pre-integration phase to determine if a planned or existing network has the capacity to provide the required AV services.

As part of systems integration, once the network is completed, a live production test should determine the actual capacity of the network.

Some tests cannot be performed on a production or pre-production network. In these instances, such a test will only be a paper-based check that the network has the capacity.

Refer to Item IT-114 Network Performance Under Full Functional Load to determine the network's ability to deliver services under stress.

Tests, Procedures, and Equipment

Testing procedure should include:

- Verifying that the network has been installed and configured for use
- For shared networks, verifying with the IT manager in the case of an existing or new network that invasive testing can be conducted
- Where invasive testing can be conducted, configuring a server to run Netperf/Iperf/Jperf or similar software to determine the networks ultimate capacity
- Running tests over a weekly or monthly cycle to capture the peak load
- Verifying the results against the AV system requirements

Measurements should include:

- Latency (response time or RTT), measured with the Ping command
- Jitter (latency variation), measured with an Iperf UDP test
- Datagram loss, measured with an Iperf UDP test
- The bandwidth, measured through TCP tests

Notes on Reporting

Note as pass/fail. Note network statistics and bandwidth.

IT-103 Network QoS (Quality of Service)

Verify that the required Quality of Service (QoS) is in place for audio, video, and data as part of either a shared network or a dedicated AV network.

Introduction

QoS is a way of providing priority to different types of traffic in a network environment. QoS encompasses loss, delay, and jitter (delay variation).

With the need to deliver voice, data, video, and videoconferencing applications over a shared or dedicated AV network, testing must address acceptance of the network and its ability to support the required content.

A number of schemes are available in networks for implementing QoS, including:

- Layer 2 parameters—802.1Q Class of Service (CoS) bits, Multiprotocol Label Switching Experimental Values (MPLS EXP)

- Layer 3 parameters—IP Precedence (IPP), Differentiated Services Code Points (DSCP), Per Hop Behavior (PHB), IP Explicit Congestion Notification (ECN), source/destination IP address

- Layer 4 parameters—L4 protocol (TCP/UDP), source/destination ports

- Layer 7 parameters—Application signatures via Network-Based Application Recognition (NBAR)

QoS needs to be implemented across the full network—not just the local area network (LAN), but the wide area network (WAN) as well.

Many WANs use DiffServ marking to manage QoS. If traffic traverses a WAN, it is highly recommended to check with the WAN provider about QoS traffic remarking. In many instances, traffic is remarked, which can reduce the traffic priority. To counter this, the LAN-based QoS scheme will need to be modified to make some types of traffic a higher priority.

QoS is important when network capacity is limited; however, it is recommended that QoS is deployed in all instances because it is generally in peak-load times when a critical audio- or videoconference needs to be made over the network. Without implementing QoS, the audio and video traffic would be heavily affected.

Each videoconferencing manufacturer provides their own guidelines for QoS. The following is a recommendation from Cisco:

Application	Layer 3			Layer 2
	IPP	PHB	DSCP	CoS/MPLS EXP
IP Routing	6	CS6	48	6
Voice	5	EF	46	5
Interactive Video	4	AF41	34	4
Streaming-Video	4	CS4	32	4
Locally-Defined Mission-Critical Data	3	—	25	3
Call-Signaling	3	AF31/CS3	26/24	3
Transactional Data	2	AF21	18	2
Network Management	2	CS2	16	2
Bulk Data	1	AF11	10	1
Scavenger	1	CS1	8	1
Best Effort	0	0	0	0

The following is a summary of key QoS requirements and recommendations for voice:

- Voice traffic should be marked DSCP EF per the QoS Baseline & RFC 3246.

- Loss should be no more than 1%.

- One-way latency (mouth-to-ear) should be no more than 150 ms.

- Average one-way jitter should be targeted under 30 ms.

- 21-320 kbps of guaranteed priority bandwidth is required per call (depending   on the sampling rate, VoIP codec, and Layer 2 media overhead).

QoS recommendations for interactive video (IP videoconferencing) traffic are that:

- Interactive video traffic should be marked to DSCP AF41.

- Loss should be no more than 1%.

- One-way latency should be no more than 150 ms.

- Jitter should be no more than 30 ms.

- Overprovision interactive video queues by 20% to accommodate bursts

IP videoconferencing (IP/VC) includes a G.711 audio codec for voice and it has the same loss, delay, and delay variation requirements as voice.

QoS recommendations for streaming video traffic are as follows:

- Streaming video (whether unicast or multicast) should be marked to DSCP CS4 as designated by the QoS baseline.

- Loss should be no more than 5%.

- Latency should be no more than 4 to 5 s (depending on video application buffering capabilities).

- There are no significant jitter requirements.

- Guaranteed bandwidth (CBWFQ) requirements depend on the encoding format and rate of the video stream.

Streaming video applications can have more lenient QoS schemes as they are delay-insensitive (the video can take several seconds to cue up) and are largely jitter-insensitive (due to application buffering). However, streaming video may contain valuable content, such as e-learning applications or multicast company meetings, and therefore would require service guarantees. When streaming video needs to buffer, screens in the same room drift out of sync, which is highly undesirable.

Tests, Procedures, and Equipment

This test requires that the network has been installed and configured for use.

To perform the test:

- Review the network configuration to verify that the required QoS scheme is in place.

- Use IT-114 Network Performance Under Full Functional Load to verify that the QoS is performing.

Notes on Reporting

Note as pass/fail. Note the QoS scheme and traffic marking.

IT-104 Network Security

Verify that the shared or dedicated network is secure as defined in the project documentation and accessible to suit the required audio, video, and control systems.

Introduction

In many cases, the AV integrator does not install the network, so if the AV systems are operating in a shared network environment this item may need to be verified by the IT contractor or IT manager.

A paper-based check should be performed in the pre-integration phase to determine if a planned or existing network will be exposed, generally by way of an IT risk assessment.

Typically, network penetration testing is run by a specialized company to ensure the security of the organization's information systems.

In many cases, information assurance or internal security departments require a sample of network-connected equipment well in advance of deployment to perform security analysis on these devices.

Tests, Procedures, and Equipment

Penetration testing can be performed in many ways, including:

- Active testing—Involves direct interaction with the component being tested for security vulnerabilities. This could be low-level components such as the TCP stack on a network device, or it could be components higher up on the stack (e.g., the web-based interface used to administer such a device). There are two distinct ways to interact with the target component: automated and manual.

  - Automated testing utilizes software to interact with a target, examine responses, and determine whether vulnerabilities exist based on those responses.

  - Manual testing—As with any automated process or technology, the margin for error always exists. Instabilities in systems, network devices, and network connectivity may introduce inaccurate results during testing. It is always recommended to execute manual direct connections to each protocol or service available on a target system to validate the results of automated testing as well as to identify all potential attack vectors and previously unidentified weaknesses.

- Passive testing—Involves metadata analysis, which consists of inspecting the data that describes a file, as opposed to the file data itself, and traffic monitoring (the concept of connecting to an internal network and capturing data for offline analysis).

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

IT-105 Telephony

Verify that any required telephony connections to the AV system are in place and connectivity is verified.

Introduction

In many AV systems, a connection to the enterprise telephony system is used for conferencing applications. There are also examples of systems tying to telephony for alarm systems and technician communications. These applications may use:

- Digital voice-over-IP (VoIP) based connections

- Private automatic branch exchange (PABX)

- Standard analog public switched telephone network (PSTN)

- Plain old telephone service (POTS) telephone lines

They may be bridged with video calls or act as a standalone audioconferencing system. Typically they are connected to the AV system via the video codec, DSP audio mixer, or simply a desktop speakerphone system.

When connecting a standard analog telephone line to the AV system, the typical connection is through an analog breakout of the PSTN phone system. These must be requested during the design and staging process. These breakouts are typically used for fax machines and can vary in quality and reliability.

The current preferred method would be to have in the AV system an adapter that is capable of connecting to an enterprise VoIP system. Ensure that the adapter is compatible with the phone system. Common connections now use session initiation protocols (SIPs) to make connections and manage the call. But while SIP is an accepted standard, most phone systems have proprietary functionalities. Therefore, do not assume that any SIP phone connection will work with another. Testing prior to purchase and installation may be prudent.

Tests, Procedures, and Equipment

Analog breakouts vary in quality. It is important to check the voltage. It is also important to check the line voltage during peak loads of the day as voltage will fluctuate due to call volume in the telephone system. Weak voltage will cause a breakdown in a connected call as the voltage goes lower than a standard phone adapter in an AV system can detect. A standard phone voltage meter should be used to verify the quality of the analog breakout.

VoIP connections should be treated like the network connection they are. Preplanning to include the AV connections to the call management systems prior to testing is necessary. Network or telephony management may need to provide network addresses for the AV devices. Any test should include calls to a bridge system if one is present within the client's network.

Notes on Reporting

Note as pass/fail. Note the configuration.

IT-106 Unified Communications

Verify that any connections to IT-based unified communication applications that will interface with the AV system have been planned for and integrated.

Introduction

As communication systems progress, the trend toward unifying all aspects of communication will increase. Communication staples, which in the past were completely independent systems (e.g., voice, video, mobile, and web conferencing), are now being integrated to work seamlessly together. Communication systems will also begin to address functions such as instant messaging, identity, and presence. Unified communications and collaboration (UCC) systems could also include scheduling systems and call management solutions. AV systems will increasingly become a part of this overall deployment.

The subject of UCC systems could take up entire books and weeks of training. The variations in UCC deployments will be vast and constantly change. There is no practical way to cover the topic in this brief section. The best way to proceed is to carefully read project documentation to determine if the system being provided will interface with a UCC system using voice, video, call management, scheduling, IM, or presence. If this will be a requirement, seek out those involved from the IT side to understand what integration will be necessary and who will be responsible for the various aspects. Preparation should begin well before equipment is physically located at the client's site.

Tests, Procedures, and Equipment

Tests should be run to ensure proper compatibility and connection to the UCC system. Some tests will simply review proper operation within the solution environment, while others will require network testing plans and equipment. It would be important to determine well in advance who will be responsible for each part of the verification and testing.

Examples of items to consider are:

- SIP licensing—Provision of adequate licensing for the AV systems.

- User licensing—Provision of adequate user licensing within the AV system (i.e., webcams or conference phones).

- Hardware interfaces—Interface products used to connect systems to webconferencing and enterprise conferencing, touchpanels, and DSP audio SIP interface modules.

Notes on Reporting

Note as pass/fail. Note the configuration.

IT-107 AV IP Address Scheme

Verify and document that all network-connected equipment has the correct IP address, subnet mask, hostname, and gateway configuration as defined in the project documentation.

Introduction

IP addresses are constructed according to a set of specific rules so that hosts on any part of the Internet or network can communicate with each other. The purpose of this item is to verify that the IP rules are followed in terms of IP addresses, subnet masks, and gateway configurations and to record them for all equipment hosted on the network.

Table 8 describes the addressing format.

Table 8 IP address formats

IP Address Version	Bit Number	Description/Example
IPv4	32 bits	Typically presented as four decimal numbers (one for each 8-bit byte) separated by decimal points, for example, 128.253.21.58.
IPV6	128 bits	Typically presented as 8 groups of 4 hexadecimal digits, for example, 2001:0db8:85a3:0042:1000:8a2e:0370:7334.

The IPv6 addressing currently is uncommon for use with AV equipment. VLANs should be configured in a manner suitable for the application. For example, an IPTV service should be grouped as a single VLAN and not divided across multiple VLANs.

Tests, Procedures, and Equipment

A spreadsheet of all the recorded IP addresses, subnet masks, and gateway configurations should be created. All AV devices that have to communicate with each other are most efficient when they are in the same subnet or VLAN.

Verify that each AV device in the system is configured to the correct VLAN.

Various software tools like NetScanner and SoftPerfect Scanner can be used to get the list of all the IP address and subnet mask information for all network devices.

Notes on Reporting

Note as pass/fail. Note the IP address listing.

IT-108 IEEE 802 Wireless Networks

Verify that the wireless network configuration is correct and valid (e.g., channel no., SSID, TX power) in defined areas of use as defined in the project documentation.

Verify that there is adequate channel separation between any client wireless networks that are required to co-exist in the same area.

Introduction

This verification item identifies that wireless devices can connect within the specified coverage zone and are configured on the correct wireless network with the correct credentials, including any security configurations that are deployed at the enterprise level over the IT infrastructure.

In many cases, the AV contractor does not install the wireless network and will be required to liaise with the IT administrator or network contractor regarding the configuration and coverage area.

If the wireless network is deployed by the AV contractor, the following considerations should be made:

- Coordinate channel separation with the owner's wireless network.

- Inform the owner of functionality limitations, such as wireless presenters not being able to connect to the screen and corporate network simultaneously.

Tests, Procedures, and Equipment

This test is part of a suite of tests that includes IT-101 IEEE 802 Wireless Security, WL-100 Wireless Audio Systems Operation, WL-101 Wireless Control Systems Operation, WL-102 Wireless Coordination, and WL-103 Wireless Video Systems Operation.

Before systems are deployed, a site survey is highly recommended to identify the channels available for use, interference present and signal propagation in relation to the space to be covered by the number of transceivers specified. If issues are detected, they should be raised to the responsible IT authority for immediate rectification.

Testing should verify:

- The AV equipment requiring to use the wireless network

- The wireless devices are compatible with the available wireless protocols

- The credentials supplied by the IT manager allow the device onto the wireless network

- If credentials are implemented by the AV contractor, they follow the owner's standards or, in absence, any national information security standards so as to not leave these systems exposed

Each system using the wireless network should be tested independently. Refer to tests in WL-100 Wireless Audio Systems Operation, WL-101 Wireless Control Systems Operation, and WL-103 Wireless Video Systems Operation. Following independent system verification, all wireless controls systems should be run simultaneously to check for interference. Typically, built-in tools will provide signal strength and assist with the diagnosis of noise.

If issues are detected, it is recommended that a second level of testing is performed using a spectrum analyzer.

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.

Check that all control signals are being received and all commands executed reliably with no intermittent control dropouts.

Notes on Reporting

Note as pass/fail. Also note the configuration.

IT-109 PoE (Power over Ethernet)

Verify that PoE (Power over Ethernet) devices are supplied with correct power required for normal device operation. Verify under practical conditions that the switch providing PoE has the capacity to power all of the devices that are connected to it.

Introduction

An increasing number of AV devices are network based. As with many network devices, AV equipment uses Power over Ethernet (PoE) to provide a single-cable installation solution. The

purpose of this verification item is to show that the devices requiring PoE are functional and are drawing the appropriate power from the network switch or inline PoE inserter.

Table 9 explains the progression of the PoE standard.

Table 9 The PoE standard

Standard	Description
IEEE 802.3af (the original version)	Dictates a maximum of 15.4 W at the power sourcing equipment (PSE) and a maximum of 12.95 W at the powered device (PD)
IEEE 802.3at (the revised version [PoE+])	Brought the power available at the PSE to 34.2 W and at the PD to 25.5 W

There are more specifics to these standards relating to current, the pairs used for power, and so on.

Manufacturers of network switches provide power in different ways. Some switches only provide power on some ports. Others could provide power on all ports, but have a maximum wattage available across all ports. The system design should account for the total power needs in the network switches specified in the project. However, a field check of the equipment provides verification that the switch is wired properly, that PoE is enabled for a specific port, and that the right amount of power is provided.

Tests, Procedures, and Equipment

A simple test is to verify that the powered devices are on and operating normally when plugged into the switch..

Certain network test devices provide a load to the switch and display the watts that are drawn from the switch. This test provides data needed to verify that the actual load isn't more than the switch is rated for. The Fluke LinkRunner AT Network Auto-Tester provides this kind of power loading. The POE1000 and POE1000il from Byte Brothers also provide loading of ports, and the il version can be used inline with the AV device to show exactly how many watts are being drawn by the device.

Use a test device that provides readout of the wattage supplied by the port and connects at the AV device location. Record the wattage available at the AV device.

Notes on Reporting

Provide a spreadsheet showing all AV devices requiring PoE. Check each device and note as pass/fail. Optionally, list the wattage provided to the device.

IT-110 Network Topology

Verify that the network for audio, video, and control is of a suitable topology to support the services to be delivered as defined in the project documentation.

Introduction

Real-time audio video and control supporting applications such as telepresence, medical procedures, and live television coverage must be in real time with the live event without a delay, which requires correct network topology and low-latency encoding/decoding.

This item should verify that the following is provided:

- A network design that provides suitable headroom above the required bandwidth
- A QoS scheme that can provide real-time services when congested
- Minimal network hops
- Low latency
- Security, but also all logical port connectivity
- Performance monitoring tools to enable management
- VLANs assigned per service (i.e., IPTV, control, video, audio)

Tests, Procedures, and Equipment

This item should verify that the network and connected AV equipment can deliver the required performance. To complete this verification:

- Review the documentation detailing the network topology if the network is provided by others or is preexisting.
- Review related verification items—IT-102 Network Bandwidth, IT-103 Network QoS (Quality of Service), and IT-114 Performance Testing Under Full Functional Load.

Notes on Reporting

Note as pass/fail. Note the topology.

IT-111 Application Integration

Verify that the AV and control systems have been integrated and have been fully configured with headend software, including monitoring and asset management; databases; web-based front ends; digital signage software and systems; content generation and distribution platforms; and appliances as defined in the project documentation.

Introduction

Application integration (sometimes called enterprise application integration) is the process of integrating software such as room management from the control system to an application program. In some installations, these programs already exist and require the platform to be updated simultaneously with integrating new systems or end-points.

A common challenge can be the integration of an existing (or legacy) program (such as room management) with a new system or with a web service or mobile app.

Often, this aspect of work is delayed until post-practical completion due to not having a range of dependencies or resources available at the time of system integration. An industry best practice for this item is to provide the full set of requirements, including IT dependencies to the client well in advance of commissioning and operation to focus on the applications' functionality rather than basic deployment.

This item should verify that the following is provided:

- Servers are in place according to the recommended specifications and commissioned with the server operating system, supporting application components, and the main application to be integrated.

- Separate SQL servers are in place and configured according to the applications' requirements, including multiple drives where required and database creator privileges.

- Applications are installed with administrator privileges.

- The email server is set up and configured with accounts and calendars for the applications server's usage.

- Servers are integrated with Active Directory or single-domain architecture.

- Servers, workstation, connected control systems, and end-points are correctly configured on the network.

- SMTP authentication is conducted via appropriate network SMTP credentials.

- Firewalls and access control lists are set to permit the bidirectional flow of data on the default application ports.

- A backup strategy is in place, which may include nightly backups of data files.

Tests, Procedures, and Equipment

This item should verify that the applications are integrated and provide two way communications between software and systems.

The tests should include:

- Verifying all systems mapping (e.g., room and devices to the rooms, screens/endpoint devices to the graphic location)

- Stepping through all system functionality (e.g., room scheduling, media scheduling, fault simulation, monitoring, reporting)

Notes on Reporting

Note as pass/fail. Note the configuration faults.

IT-112 Enterprise Management Tools

Verify that enterprise management tools such as central monitoring client/server or web-based applications have been installed and connected to all systems they are required to monitor or control as specified in the project documentation.

Introduction

This verification item identifies any tools that manage the AV equipment deployed at the enterprise level over the IT infrastructure (LAN, WLAN, or cloud-based). One example would be a centralized management system for all videoconferencing codecs deployed across the enterprise network of a corporation. The system should be tested to ensure that all installed codecs are registered to the central management tool and that user access and access levels are set up for the required personnel.

The documentation shall list all managed rooms and devices in cases where a full management system is being used, such as:

- Proprietary solutions for AV device management (e.g., AMX RMS, Crestron Fusion RV, Extron Global Viewer Enterprise, lighting system management)

- Open-source AV device management solutions such as USM

- Network performance monitoring tools

- Open building integration solutions such as Bacnet

In addition, the documentation shall clearly list which data are being referenced in the main dashboard (i.e., lamp hours, systems power, projector input, in-call videoconferencing).

Tests, Procedures, and Equipment

The contractor shall list all systems, devices, or tools requiring remote management across the enterprise network. Each item shall be listed and then tested from the remote application or server.

All connected codecs and the call status of the codecs shall be verified and listed in the report documentation if the documentation calls for central enterprise management of video codecs. Exact testing is dependent on the type of enterprise system defined in the system documentation.

Notes on Reporting

Provide a list of enterprise management items and show each item as pass or fail.

IT-113 Identity Management Plan

Verify that all systems authentication credentials are configured correctly. Any temporary credential used during system installation and commissioning should be removed.

User and group authentication and authorization are verified based on the requirements from the project documentation. Connectivity with the central directory, database, or other identity authority should be verified.

Introduction

Identity management covers a broad scope of possibilities in a system. It could range from a simple username and password to access a digital signal processor for a user control screen to integration with an Active Directory-type data structure that would import names into an

enterprise-wide UCC contact list. Another possible application would be user rights for logging into a digital signage display system.

Specific login credentials would not only allow entry into the systems but might also have levels of permission about content that could be created, where it can be displayed, and who has approval rights to actually allow the content to be posted. Certain AV systems may be programmed to offer different user controls depending on who logs into the system.

The system specifications should spell out who is responsible for providing the user data, the format or structure of the data, and how it is to be deployed.

Tests, Procedures, and Equipment

Test the logins using known and approved login credentials to verify connection to the credential database, whether on a remote server or native to the device or application. These tests should be performed directly with or guided by the client's IT security representative.

Notes on Reporting

Provide a signed statement by the client's IT security representative or project representative confirming that the identity management verification shows the proper credentials are created or available through the AV system referenced in the documentation. Such a statement may cover multiple systems in the same AV project (e.g., security cameras, digital signage software, audio DSP devices).

IT-114 Network Performance Under Full Functional Load

Verify that the network can provide the required operational performance to carry control, audio, video, and data under production load and at times of peak production load (refer to IT-102 Network Bandwidth).

Introduction

In many cases, the AV integrator does not install the network, so this item may need to be verified with the IT contractor or IT manager, if it has already been installed.

Some tests cannot be performed on a production or pre-production network. In these instances, this test may need to be a subjective test only.

If it's a subjective test, determine the time and length of the network's peak. This is especially critical on shared networks where total load demands may be managed directly by IT staff or remain unknown.

Tests, Procedures, and Equipment

To perform this test:

- Verify that the network has been installed and configured for use.
- For shared networks, verify with the IT manager in the case of an existing or new network that invasive testing can be conducted.

- Where invasive testing can be conducted, configure the server to run a packet generator.

NOTE A packet generator test involves the run-up of the pre-production network using a packet generator to flood the network. While the network is under load, run AV services simultaneously.

- Should invasive testing not be allowed, such as the use of a packet generator, this test can be run at known times of peak production load for a shared network.

Qualitative performance testing should be completed for each service using the network, including (but not limited to):

- Control systems

- Videoconferencing

- IPTV

- Video streaming

- SIP-based audioconferencing

- Audio over the network (e.g., public address)

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale	
Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using specialist protocol analyzers to review network bandwidth, bit error rates, packet loss, and processing and timing issues is recommended.

Notes on Reporting

Note as pass/fail. Note the statistics.

IT-115 Remote Access

Verify that remote access to AV and IT systems is configured as defined in the project documentation.

Introduction

This verification covers the ability of the service provider to access the AV and IT systems installed from a remote location. The scope and function of the access shall correspond to the project documentation.

Tests, Procedures, and Equipment

List the specific systems requiring remote access per the documentation (i.e., control system, audio DSP, VC codec). List the type of remote access being used (e.g., VPN, a computer's remote desktop control).

From a computer outside the LAN/WAN of the system under test, verify a connection can be made to each system or device listed above.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

IT-116 Remote Management

Verify that remote management tools such as virtual touchpanels, internal web applications, or manufacturer's applications are configured and functional as required by the project documentation and/or manufacturer's specification.

Introduction

This verification item identifies the parts of the AV system that provide access from remote locations, generally over the network. The responsible parties for the owner's IT systems shall be made aware and approve of any part of the AV system that requires remote access within the IT network. For systems that require access from outside the owner's network, refer to systems verification item IT-115 Remote Access.

This verification item would apply to systems like a browser-based digital signage system (using a browser to access a centralized server), PC-based touchpanel emulation, or a full AV device management and reporting system.

In cases where a full management system is being used (i.e., AMX Room Manager, Crestron, Fusion RV, Extron Global Viewer Enterprise, lighting system management), the documentation shall list all managed rooms and devices. In addition, the documentation shall clearly list which data is being referenced in the main dashboard (i.e., lamp hours, systems power, projector input, in-call videoconferencing).

Tests, Procedures, and Equipment

The contractor shall list all systems, devices, or tools requiring remote access from within the IT network (LAN or WAN). Each item shall be listed and then tested from the remote application. For instance, control system web-based touchpanel emulation files shall be shown to work from a remote PC within the facilities network. Exact testing depends on the type of remote access defined in the system documentation.

Notes on Reporting

Provide a list of remote management items and show each item as pass/fail.

Operations and Support

Verification items within this category verify that operational planning and handover of elements of the system have been conducted and conform to requirements provided within project documentation. Project-specific verification items that support planning for operations or address handover elements shall be listed in this section.

OP-100 Software

Verify that all control programming code, DSP configuration files, and any other associated software have been provided as defined in the project documentation.

Introduction

List by room or location all devices that require specific software or programming. Provide that list along with copies of the files to the owner. The list should have a place where the customer can sign off that they have received the software.

Examples include:

- Uncompiled control system code (depending on the specification)
- DSP programming software and the actual files specific to the project
- Configuration files for equipment like network switches, and video scalers
- Digital signage layouts or templates
- Any other software listed in the specification documents

Tests, Procedures, and Equipment

The primary task is to verify that solutions exist and that, if solutions are provided, they follow the project documentation.

Notes on Reporting

Submit a list of all software with the signed documentation from the customer showing the software was received.

OP-101 Battery Management Plan

Verify that a battery management plan has been completed and supplied in the project documentation package to owner.

Introduction

The purpose of the battery management plan is to prevent situations where equipment is not ready for use or becomes unusable and limit battery waste in landfills. The battery management plan should follow the project specifications and be submitted with the final documentation.

Such a plan should consider:

- Equipment requirements—Details of batteries required for all equipment (i.e., AA 9 V lithium ion proprietary)

- Special battery replacement (i.e., for button cells in control systems)

- Sources of spare batteries

- Guidance on typical battery life for expected usage patterns

- Battery management routine (e.g., regular replacement requirements)

- Battery charging procedures

- Battery disposal or recycling (depending on the region)

Tests, Procedures, and Equipment

Review the owner's project documentation package to verify that there is an adequate battery plan.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

OP-102 Content Management Plan

Verify there is a plan for managing the content to be delivered by the AV systems, including the means to create content and update content when new information needs to be conveyed.

Introduction

The project documentation may reference a management plan for the delivery and creation of AV content used with the system being installed. If a plan is referenced, the AV systems shall be compatible.

It is normally the domain of the client (e.g., engineering, IT department, external provider) to produce a plan. Such a plan typically identifies the following:

- Persons responsible for creating the content

- Methods of content delivery (format and medium)

- Methods of cataloguing and referencing the content

- Persons responsible for loading the content if it is file based

- Persons responsible for updating the content

In many instances, a content management plan is not generated, and the system is handed over without content, which is not ideal.

Tests, Procedures, and Equipment

The primary task is to verify that if a plan exists and that the solution provided follows the plan.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

OP-103 System Content Provided

Verify that any owner, vendor, or third-party-produced system content that is required for operations as defined in the project documentation has been supplied, loaded, and tested in the completed AV system.

Introduction

For systems like digital signage, in addition to managing the installation of the physical equipment, it is also necessary to verify that any content (video or audio, in any format) is delivered as part of the project.

The content management plan shall provide a detailed list of the content to be provided for the project as determined as part of OP-102 Content Management Plan.

Tests, Procedures, and Equipment

Obtain the list of content material from the content management plan.

If the content management plan does not exist or is incomplete then the contractor may encourage the client/necessary parties to create it.

Many clients expect that the system is turn-key and that content is provided as part of the system delivery. While this is a newer area of business for AV contractors, in most installations, content is either part of a separate contract or is supplied by the client directly.

To proactively manage scope and expectations, it is suggested that the subject of content delivery be raised several times in the delivery phase to ensure that responsibility for content is clear. If the content creation responsibility lies with the AV contractor, it is recommended that a content signoff procedure is put in place.

Notes on Reporting

The notes section should reflect the responsibility for and the party tasked with updating any content. Normally, the contract or project documentation covers these responsibilities and the parties involved. This should be noted for easy future reference.

Physical Environment

Verification items within this category verify that built elements that interact with a system perform and conform to requirements provided within project documentation. Guidance is provided on all verification items listed in the Standard, which includes structural reinforcement, lighting, enclosures, finishes, and other built elements.

PHYSE-100 Divisible Spaces

Verify that the divisible spaces provide the functionality specified as defined in the project documentation.

Introduction

This item is to verify that all systems and subsystems within the divisible space have been installed and are functioning as specified in the project documentation. Testing must be performed in multiple phases: each subsystem individually and then the combined system.

Tests, Procedures, and Equipment

Test the operation of each portion of the divisible space separately. Then, test the operation of the space in combined mode. Verify that all features are fully operational as specified in the project documentation.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-101 Human Factors, Usability, and Ergonomics

Verify that ergonomics and usability elements for audience and system users are installed and configured as defined in the project documentation.

Introduction

The verification of this item is driven solely by the project documentation because no common benchmarks exist in the absence of a design direction. Without direction, this item will generally provide a pass should it meet a fitness for purpose test.

This item covers the ability of people to use the system and is fundamental to the success of the system. Examples of elements that should be verified in accordance with project documentation are:

- Accessibility of inputs, so the users are not required to search for a place to plug in a mobile or portable device

- Providing guest facilities so software does not need to be installed to use in-room equipment, such as wireless presenters

- Providing presenters a with view of their presentation content while facing the audience so they do not need to bend down or look away

- Providing self-view and camera presets or automated pan-tilt-and-zoom (PTZ) facilities for videoconferencing while facing the camera to maintain eye contact

- Optimum camera locations to maintain eye contact and not have the far end positioned and looking down or up relative to the near end

- Providing height adjustment to lecterns, microphones, and other devices to suit the users' height range

- ▪ Designing touchpanels to enable all key room setup and videoconferencing endpoints to be applied with a maximum of only three touches/clicks and a small range of movement

Tests, Procedures, and Equipment

Verify that considerations have been made for the end user's ease of physical access to system operational controls and all AV equipment requiring direct user operation and allow convenient access to system inputs/outputs in support of portable equipment supplied by end users. These ergonomic considerations should take into account use by both able-bodied users and users with special needs.

Notes on Reporting

No specific notes on reporting are required for this item.

PHYSE-102 Lighting

Verify that the lighting systems are suitable for each type of application (e.g., videoconferencing, presentation, broadcast, performance) as defined in the project documentation. This verification item should require a metric to be verified.

Introduction

This item covers the artificial lighting systems that would be installed by an electrical contractor only. Daylight has a major impact on the installation, depending upon the building's apertures, window shading co-efficient, orientation, and architectural controls (e.g., louvers and blinds). An additional test to review the implications of daylight control is recommended. Testing will be required throughout the course of a full-sun day and, depending on geographic location, may need computerized modeling to fully predict the sun during the course of a year.

Test the sensitivity of room occupant sensors, touchpanel functionality, wall button panels, and theatrical dimming systems such as DMX512 for integration with the AV control systems and ensure each application has correct settings.

Lighting systems and the AV control system should be jointly verified in cooperation with the lighting control system programmer. This arrangement will allow adjustments to lighting levels within each preset and provide settings for the best possible video image.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	Minimum emergency lighting requirements
2. Project Documentation	

3. InfoComm Standards	IES/INFOCOMM RP-38-14 (draft), *Videoconferencing Lighting*
4. Other Standards	
5. Manufacturer Documentation	Application-specific guidelines
6. Other Best Practice Documentation	InfoComm/BICSI. 2006. *AV Design Reference Manual*. IESNA. *The Lighting Handbook Reference and Application*. IESNA. *Fundamentals of Lighting for Videoconferencing.*

Metric Selection

Lighting metrics (luminance and illuminance) vary depending on the application. This section defines two common applications and proposed metrics:

- Task-based lighting—People reading or analyzing content on a tabletop surface. There must be enough light falling on the table for people to comfortably interpret what they are seeing (IESNA's *Lighting Handbook*):

  - Classroom table surface 300 to 500 lux

  - Lecture hall 400 lux

  - Conference rooms 300 lux

- Videoconference lighting—People in one location are visually interacting with others in at least one remote location. In this environment, how people appear on camera is critical. It's not entirely about the light levels produced in the room, but the image produced by the camera. This environment is very complex and requires significant infrastructure and lighting design. Here are a variety of metrics to consider from IESNA's *Fundamentals of Lighting for Videoconferencing,* page 9:

  - Participants (vertical illuminance) 300 to 500 lux

  - Walls 200 to 400 lux

  - Display spill light 200 lux or less for direct view, 150 lux or less on rear screen projection systems, 50 lux or less on front projection systems

  - Lamp color temperature 3000 to 3500 K

  - Wall finishes 40–60% reflectance

  - Table surface 20–60% reflectance

NOTE InfoComm is working jointly with the Illuminating Engineering Society (IES) on a new videoconference lighting standard, IES/INFOCOMM RP-38-14, *Videoconferencing Lighting*. It is now in the draft phase and will contain performance criteria and process for achieving conformance. Visit infocomm.org/standards for more information on this standard.

Tests, Procedures, and Equipment

Testing consists of using an appropriate lightmeter (spot photometer or illuminance meter) to take measurements as indicated in the publication or standard referenced in the project specifications.

Notes on Reporting

Create a floor plan indicating furniture placement and locations where measurements were taken. A document listing the results and pass/fail status should also be made.

PHYSE-103 Vibration

Verify that the physical environment is suitable for the intended AV systems in relation to all sources of vibration affecting stability of equipment such as videoconferencing cameras, document cameras, and fixed screen and projector locations.

Introduction

Verify the building systems are completed with plant and equipment running at full building load, such as air-conditioning, diesel generators and other equipment that has variable output depending up load and duty cycles. Testing must also take into account external variable factors such as adjacency to all sources of vibration (e.g., street cars, heavy rail, flight paths and major transport routes).

Projectors, cameras (e.g., videoconferencing document, monitoring), screens (e.g., rear projection, ceiling), and mirrors can be affected by vibration.

Tests, Procedures, and Equipment

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale	
Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using low-frequency vibration analysis with an accelerometer is recommended.

Quantitative testing of less than 100 micrometers/second (μm/s), root mean square (RMS) as measured in 1/3 octave bands over the 1 Hz-to-1 kHz frequency range.

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent vibration issues and during times all systems are running.

Testing should include scenarios where cameras are fully zoomed in to accentuate vibration effects.

Notes on Reporting

Note as pass/fail. Note visual qualitative results and any periodic vibration occurrences (e.g., passing trains, results during a generator test, results when the air-conditioning plant starts up).

PHYSE-104 Backing/Blocking/Framing

Verify that installed backing, blocking, and framing meets project documentation requirements and industry standards for installation means and methods.

Introduction

The structural accommodations associated with AV equipment—backing, blocking, and framing—are to be verified for proper configuration, placement, and compatibility for the intended application. All backing, blocking, and framing will be installed as directed by the project's authority having jurisdiction (AHJ) for structural design and implementation oversight.

Tests, Procedures, and Equipment

Tests and procedures should include:

- Comparison of the project design documents to the submittal documents of mounting hardware, AV equipment, and intended use for compatibility
- Visual inspection of final backing, blocking, and framing installation

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-105 Clean Building Handover

Verify that the area is clean and dust-free and suitable for equipment installation and that no further work is planned that will release contaminants into the AV equipment area. Verify that the area released is isolated from any areas not yet released.

Introduction

This item is to verify that all building construction has been completed and the space is prepared for the installation of the AV system components. Spaces where AV equipment is to be installed (i.e., equipment rack closets, rear projection rooms, accessible spaces) must be fully constructed, cleaned, and prepared prior to the start of the AV installation.

Tests, Procedures, and Equipment

Visually inspect the areas where the AV equipment is to be installed. Verify that it has been cleaned, vacuumed, and dusted.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-106 Coordinated Construction Elements

Verify that the elements including but not limited to spatial requirements and building services required by the AV system that are coordinated with other disciplines have been provided per the project documentation.

Introduction

This item is to verify that all construction elements required for a complete and fully functional AV system have been properly coordinated and are in place prior to the start of the AV installation.

Verify that walls, ceilings, floors, infrastructure (such as conduit/containment, floor boxes, and ceiling tile supports) and other similar building elements are fully constructed, supported, and prepared for the installation of the AV system components. Ensure that lighting and AV control systems are operational and ready to be commissioned. Verify that electrical, HVAC, communications and other similar building systems and/or services have been installed and are fully functional.

All of these supporting services must be coordinated with the appropriate trades early enough in the construction process to ensure that the AV system can be fully integrated into the space and to avoid unnecessary change orders.

Tests, Procedures, and Equipment

Visually inspect all building systems required for the installation of the AV system as defined in the project documentation. Compare the results with engineering drawings and specifications and document any discrepancies.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-107 Device Enclosures

Verify that device enclosures accommodate the intended device and that all necessary environmental controls (e.g., heating, cooling, humidity) are incorporated into the enclosure as defined in the project documentation.

Introduction

A device enclosure is any enclosure with AV equipment inside. It could be a cabinet of a teacher podium housing a rack of AV equipment, a credenza in a business conference room, a wall box with a security cover over a touchpanel, a roll-top desk for a soundboard at a church, or an environmental enclosure for a security camera.

Enclosures serve different functions—security and protection for the equipment, aesthetic considerations for the space within which they are located, and the functional use and access to the equipment. Since some manufacturers' warranties may not be valid if the device is not installed correctly into an enclosure, it is important to verify the fit and usage of the devices within an enclosure. Rack thermal performance is covered under PHYSE-101 Human Factors, Usability, and Ergonomics.

This verification covers three basic questions:

1. Does it fit as intended?

2. Is it usable/accessible as configured?

3. Are the required environmental controls provided (i.e., heaters, fans, ventilation)?

All three are based on the specifications listed in the project documentation.

Tests, Procedures, and Equipment

A visual inspection of all AV equipment shall be performed. A list of the equipment with three columns (Fit, Usability, and Environmental) shall be made and each item checked off the list showing that it meets the project documentation's specifications.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-108 Finishes

Verify AV equipment, furniture, fixtures, and accessories against the project documentation.

Introduction

Depending on the project, finishes may be expressly specified in the documentation, or may be referenced as the AV contractor's task of to coordinate with another party. An example taken from bid documentation states that such a task includes "Coordinating with the Architect and Owner on final color selection, and/or the painting of any exposed loudspeakers and any/all exposed system components to match the room's aesthetics and finishes."

The review shall cover the submittal of color choices or samples, the approval documentation, and a final visual inspection of the equipment to ensure it matches the submitted and approved samples.

Tests, Procedures, and Equipment

List all devices, equipment, or surfaces that require a sample or color choice approval. Provide documentation showing colors or samples were submitted for review. Provide documentation showing the colors or samples that were approved.

After the equipment is installed, perform a visual verification of each item by comparing the item to the sample material that was submitted. Indicate on the list of items that each item passed the visual inspection.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-109 Floor Boxes/Wall Boxes/Ceiling Boxes

Verify that installed floor, wall, and ceiling boxes meet project documentation and regulatory authority requirements.

Introduction

Device enclosures, whether in the floor, walls, or ceiling, can have a very negative impact on a project if not carefully tracked throughout the project process. Changing a floor box that is the wrong size for the devices, plates, or terminations after it has been poured into concrete can be costly.

Tracking these devices is complicated by the fact that the specification may call them out as part of a general contractor's bid, an electrical contractor's bid, or a bid by another non-AV trade. It can also be the case that the AV bid for a project may not even be awarded until long after the boxes are in place.

It is best practice to review submittal documentation related to enclosures (when provided by others) to make sure that, if any substitutions are made, the actual product approved matches the original or has better specifications.

Suppose two brands of an 8-in floor poke through device look nearly identical in all respects, except one version has a full 2.5-in depth behind the faceplate and the other only has 1.5 in. While both may appear to meet the specifications, a small difference like this is often missed by the electrical engineering review of the submittal documentation. However, the 2.5-in deep video transmitter device will not fit into the one that was actually installed in this project.

Tests, Procedures, and Equipment

Review all floor, ceiling, and wall boxes to verify that they meet the specification for size, finish, and location. This should be reviewed at the following stages:

- Submittal phase
- If installed by another trade, when product arrives on site
- After the installation of the enclosures/devices
- After the installation of any equipment, plates, or terminations within the enclosures

Notes on Reporting

Note as pass/fail. Items to check include proper device, proper fit (e.g., level, plumb, square), proper location, and proper finish. On a plan or elevation view, check off or initial each device or enclosure as having passed the review and include the date of review.

PHYSE-110 HVAC Commissioned

Verify that the HVAC system has been tested and balanced prior to completing verification items AP-112 Acoustical Ambient Noise and AP-116 Audio Level Exceeds Background Noise Level.

Introduction

This item is to verify that the HVAC system has been installed, tested, and balanced properly as defined in the project documentation. The HVAC system will have a significant impact on the AV components that have been installed in the same space (i.e., vibration, noise, thermal).

Tests, Procedures, and Equipment

Start up the HVAC system and verify that the system is functioning per the HVAC specifications. Document any issues discovered.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-111 HVAC Operation

Verify that the HVAC system has begun continuous operations in advance of equipment operations.

Introduction

This item is to verify that the HVAC system has been started and is currently in operation. Several verification items in this document require that the HVAC system is operational prior to being tested.

Tests, Procedures, and Equipment

Verify with the HVAC installer and the owner's representative that the system has been started and is functioning per the HVAC specifications.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-112 Structural Mounting

Verify configuration and compatibility of structural accommodations and all mounting hardware based on the intended application. All equipment mounting hardware shall be installed in the manner specified by the hardware manufacturer.

Introduction

Structural accommodations and all mounting hardware are to be verified for proper configuration and compatibility with the intended application. All equipment-mounting hardware will be installed in the manner designated by the hardware manufacturer or as directed by the project's authority having jurisdiction (AHJ) for structural design and implementation oversight. No modification of pre-manufactured equipment-mounting hardware will be accepted.

Tests, Procedures and Equipment

Compare submittal documents with the mounting hardware, AV equipment, and intended use for compatibility. Complete a visual inspection of the final installation.

Notes on Reporting

As simple pass/fail reporting is all that is required by the Standard.

PHYSE-113 Protection of Installed Equipment

Verify that all elements of the AV system are free of damage.

Introduction

This item is to verify that all specified equipment has been installed and is free of damage or defects that would affect the performance, aesthetics, and life of the system. Such verification covers all rack-mounted equipment as well as devices and components that are installed within the space. Minor scratches or similar cosmetic damage may be acceptable as defined in the project documentation.

Tests, Procedures, and Equipment

Visually inspect all AV equipment for damage. Document any damage discovered.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSE-114 Accessibility

Verify that all systems are accessible in accordance with regulatory requirements.

Introduction

This item is to verify that all user controls and other devices requiring user interaction (i.e., control panels, media players, input/output devices) have been installed in the proper manner to allow for accessibility for all users regardless of physical height and ability/disability.

Tests, Procedures, and Equipment

Visually verify that all equipment intended for user interaction has been installed per established codes and regulations.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

Physical Installation

Verification items within this category verify that the workmanship for installation of all the equipment within the system except cabling conforms to requirements provided within project documentation. Guidance is provided on all verification items listed in the Standard, which includes containment, installation, security, and equipment cleanliness.

PHYSI-100 Cable Containment/Conduit

Verify that installed containment/conduit capacity and routes meet project documentation requirements, industry standards, and regulatory requirements for installation means and methods.

Introduction

Electrical codes require that the conduit only has a certain quantity of wiring inside and that the wiring meets code for wire and signal type. While it is beyond the scope of this document to cover every possible type of conduit-fill specification and wire type code, it is the responsibility of the contractor to abide by all codes and laws in force for the location of the installation.

The project documentation should call out appropriately sized conduit or wire path devices. This item is intended to visually verify that that the proper conduit was used and that the correct wire types and quantity were installed in the conduit.

Information sources include:

- NFPA 70®, *National Electrical Code*®/AS/NZS 3000 and *Electrical installations* (known as the Australian/New Zealand Wiring Rules)/IET Wiring Regulations (BS 7671)

- InfoComm Design Online, section Conduit Capacity

Tests, Procedures, and Equipment

Visually verify the following as pass/fail:

- Cables are routed through conduit based on different signal types.

- Power and AV wiring are correctly isolated from each other.

An example based on U.S. codes for conduit fill includes:

- A single cable in a conduit shall be 53% of the conduit.

- Two cables shall be 31% of the conduit.

- More than two cables shall be 40% of the conduit.

Each room or location shall be noted as pass or fail based on the visual inspection of the cable conduit or raceway.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSI-101 AV Rack Air Flow and Temperature Performance

Verify that the AV rack(s) provides the airflow as required in the project documentation.

Verify that the temperature in the AV rack has been measured and is within tolerances defined by manufacturers' guidelines and the project documentation.

This verification item shall require a metric to be verified.

Introduction

This item covers the heat dissipation and thermal regulation for AV racks and the space in which it is contained. There are various methods for handling heat dissipation within a rack and within the enclosing physical space. Regardless of the method deployed, the equipment should remain at an acceptable operating temperature to prevent the equipment from failure due to overheating and reduced life due to prolonged overexposure to high temperatures.

Equally important to the design and implementation of the rack is the HVAC system, which controls the space in which the rack is enclosed. Without proper in-room ventilation, even a perfectly implemented rack will not properly dissipate heat. The heat output of the rack within the space and any other heat sources should be taken into consideration.

Special consideration may need to be given in cases where the facility's HVAC operation changes due to seasons, holidays, or weekends. When the equipment racks are left powered continuously, the HVAC systems must operate matching hours.

In some circumstances, the lower end of the operating temperature range for equipment may also need to be considered if an installation is undertaken in a very cold environment.

Information Sources

To define metrics required for testing, refer to the following documentation in order of precedence:

Information Type	Information Source
1. Regulatory Requirements	
2. Project Documentation	Specified operating temperature range
3. InfoComm Standards	
4. Other Standards	
5. Manufacturer Documentation	Equipment-specific temperature ranges
6. Other Best Practice Documentation	

Metric Selectiona

In the absence of project documentation and/or specific manufacturer requirements, the thermal gradient performance of the rack should operate so that each piece of equipment remains below 24.5 °C (85 °F).

Tests, Procedures, and Equipment

The following tests and their associated procedures are required to complete this verification item:

- Review the airflow and ventilation provision (e.g., fans, vents, supply air) actually provided against the stated requirements from the project documentation.

- Measure the surface temperature at six locations—front and rear surfaces at top one-third, middle one-third, and bottom one-third of rack—and record the reported operating temperature of any operational equipment.

A simple temperature-probe measuring instrument is all that is required for this test. If a time-based temperature recorder is available (or even a maximum/minimum logger), it would be beneficial to run a test over a 24-hour period to account for HVAC operation variation.

Notes on Reporting

Record the temperatures at each location within the rack and record a pass/fail result against the system measurements overall.

PHYSI-102 Equipment Security

Verify that equipment is secured as defined in the project documentation.

Verify that all security systems, devices, and manufacturer security accessories are installed and verified to be operating as defined in project documentation.

Verify that keyed devices have been keyed as defined in the project documentation and devices requiring configuration have been configured as defined in the project documentation and are verified to be operating within specification.

Introduction

This item is to verify that all equipment specified as requiring secured installation procedures has been installed per the manufacturer's instructions and as defined in the project documentation.

Tests, Procedures, and Equipment

Visually inspect all security hardware and physically test locks for proper functionality. Refer to specifications for project-specific requirements and document any non-conformance.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSI-103 AV Equipment Labeling

Verify that all AV equipment has been labeled in accordance with the requirements of the project documentation. All labeling must be consistent, durable, accurate, and visible without dismantling of sub-assemblies.

Introduction

This item is to verify that all equipment items are properly labeled and identified. All equipment items should be marked for ease of identification. The equipment label should match the device label within the systems diagrams.

Tests, Procedures, and Equipment

Visually inspect equipment, verifying label and labeling convention. Refer to specifications for project-specific requirements and document any non-conformance.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSI-104 Plumb and Level/Square

Verify that all AV equipment has been installed, aligned, or angled correctly as defined in the project documentation. Level and plumb are the default requirement unless particular angles or other alignments are defined in the project documentation.

Introduction

Refer to the project documentation for mounting details. All devices should be installed plumb and level/square in relationship to architectural elements within a space. An exception for this would be for loudspeakers that are often mounted on an angle based on dispersion patterns and desired coverage area.

Tests, Procedures, and Equipment

Visually inspect the installed equipment using the appropriate level- and/or angle-measuring device. Refer to the specifications for project-specific requirements and document any non-conformance.

Measurement equipment varies from the basic spirit level (bubble level) to laser and electronic type levels that also can provide angle measurements. The installation activity and requirements would dictate the device required.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSI-105 Site Security

Verify that all elements of the AV system are free from loss, damage or tampering.

Introduction

This item is to verify that all equipment specified to be provided as part of the AV system has been installed per the manufacturer's written instructions and as defined in the project documentation and is without any damage or defects.

Tests, Procedures, and Equipment

Visually inspect all AV equipment for damage or tampering. Inventory all equipment to verify that all specified devices and accessories are present and accounted for. Document any missing equipment.

Take special precautions to prevent construction and unintentional damage. An example would be to use temporary coverings and wraps to protect finishes from bumps and scratches.

Ensure that the spaces where the AV equipment is installed are properly locked.

Site security should ensure that the construction site is secured and not accessible to the public and is controlled to a limited range of known personnel for auditing in case of theft. Each space where the AV will be installed should have controlled access.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSI-106 AV Equipment Located Per Project Documentation

Verify that AV equipment is installed at the location and/or in the rack or enclosure as defined in the project documentation. Equipment is installed per the elevation or other specification provided by the project documentation or the manufacturer's specification.

Introduction

The project documentation spells out specific locations for the AV equipment within a project. This verification item is a post-installation check to ensure that the equipment is located as specified. Items to review and consider include:

- Height of equipment based on elevation drawings (e.g., height to the bottom of a projection screen, clearance below a TV or projector suspended from a ceiling, wall mounted control panels, and program speaker height)

- Devices centered on walls or between physical boundaries

- Equipment within a rack matching the rack elevation drawings

- In multiroom systems, correct models or types of unit present (55-in TV instead of a 46-in TV)

Verify the location of ceiling-mounted items (e.g., projectors, screens, speakers, cameras). Verify the location of floor-mounted AV equipment including floor boxes or poke-through enclosures and the AV equipment intended to reside in those boxes or devices. Verify movable equipment meets the criteria through the full range of movement. For instance, verify a projection screen case location, and verify the position of the screen when it is down for viewing.

Tests, Procedures, and Equipment

Visually verify the following as pass/fail:

- Using the elevation drawings, measure actual AV equipment locations against measurements shown on the drawings. Highlight or check each item as correct or incorrect.

- Using plan drawings, verify the physical location of the device, rack, AV furniture, and so on. Highlight or check each item as correct or incorrect.

- Using the reflected ceiling plan, verify the physical locations of the device, speaker, projector, and so on. Highlight or check each item as correct.

Notes on Reporting

Final documentation shall consist of a copy of the elevation, plan, and reflected ceiling plan drawings and any other pertinent drawing. Each piece of AV equipment shall have a check or highlighting noting that the device has passed or failed the location verification.

Specifically with ceiling mounted equipment, verify any conflicts between the AV equipment and other, non-AV equipment. In some cases, the AV equipment may be located according to the documentation, but, due to coordination issues, there may be a conflict. An example would be a ceiling speaker blocked by a large lighting fixture.

PHYSI-107 AV Rack Cleanliness

Verify that all components installed in AV equipment racks are free from dirt, dust, water, or any other element that would compromise the performance and/or longevity of the AV system.

Introduction

This item verifies that the AV equipment racks have been installed properly and are clean and free from any environmental elements that could present damage to the equipment.

Common things to inspect include:

- Dust and dirt

- Water and other liquids

- Cable tie remnants

- Wire remnants

- Tools and superfluous equipment

In some installations, insect or other infestation can be a problem and should be identified and reported.

Tests, Procedures, and Equipment

Visually inspect all AV equipment for dust, dirt, and water.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. Document any detrimental items discovered.

PHYSI-108 Non-End-User Controls Protection

Verify that installed items with user-facing controls that are not intended for end-user access have been covered, disabled, or otherwise secured to prevent end-user operation.

Introduction

AV systems often have equipment in a rack that, by design, is intended to be adjusted by the end user. There may be equipment with controls that are set by the AV contractor and should not change or be adjusted by the end user. For instance, a mixing console is meant for a user to adjust the levels during an event. The input gain on the amplifiers in the same system or EQ filters set specifically to meet the loudspeaker manufacturer's performance specifications are normally set for optimum system performance and should not be changed once the system ownership is transferred to the owner.

Physical equipment may be locked in a rack cabinet or rack-mount security covers used to keep specific pieces of equipment protected. For digital equipment, front-panel controls can often be locked out or a user interface can be designed so only the controls intended for access by the owner can be created. The same applies to touchpanels in a control system.

Enabling full menu controls on a projector may not be necessary or advisable since users can then modify the settings calibrated by the AV contractor.

Tests, Procedures, and Equipment

If a list of equipment is not provided in the documentation indicating which devices should be secured from end-user adjustment, create such a list. Check that each item on the list is secured to prevent changes to the equipment beyond what is expected in a normal use scenario for the system.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSI-109 Optical Components Cleanliness

Verify that all optical components, such as lenses and mirrors, are free from dirt, dust, damage, or markings that would compromise the optical performance of those system components.

Introduction

This item is to verify that all lenses, mirrors, and other optical components have been installed properly and are clean and free from any element that would occlude or otherwise adversely affect imaging or present damage to the optical components..

For image geometry details, refer to VP-104 Image Geometry.

Tests, Procedures, and Equipment

Visually inspect all lenses, mirrors, and other optical components for:

- Fingerprints
- Dust and dirt
- Scratches
- Distortion
- Cleaning residue
- Alignment and focus

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard. Document any detrimental items discovered.

PHYSI-110 Handling of Accessories Otherwise Undefined

Verify that all items that may have been pre-packaged with primary system equipment but which have no documented planned use in the AV system(s) are managed in accordance with the project documentation.

Introduction

Many pieces of AV equipment are shipped with accessories that are usually not necessary or only have limited use once the system is fully installed and operational. For instance, a projector remote control is usually not necessary for the normal use of the system when a control system is also being used in the system. However, there may be specific menu functions that need to be accessed for service calls that would require the remote to be saved and available when the time arises.

The system documentation should reflect the process for saving, organizing, and turning over these extras at the end of the project. If no specific instructions are provided in the documentation, it is the AV contractor's responsibility to organize the accessories and provide them to the owner.

Tests, Procedures, and Equipment

Provide the end-user documentation showing the types of accessories and method of transferring them to their possession. Have the end user sign the documentation acknowledging receipt of the equipment. If no specific documentation exists, create a basic equipment inventory that the owner can sign. It can be a straightforward document. An example would be, "27 projector remotes, 10 LCD TV remotes, 12 video receiver power supplies, 4 wireless microphones, and miscellaneous rack hardware."

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

PHYSI-111 Turnover of Accessory System Elements

Verify that any equipment that may be considered "portable" and/or otherwise not specifically incorporated into the installed AV system(s) has been set up, configured, and tested.

Introduction

This verification item covers any equipment or systems that are not permanently installed in a room or location. For example, an installation for a hotel may include a ballroom audio system but may also include small portable audio systems for small conference rooms or a small performance venue.

Another common set of items would be products such as wireless microphone transmitter packs, wireless voting devices, hearing assistance receivers, charging bases, or any device that may be stored in one location and used in another.

Tests, Procedures, and Equipment

Set up the equipment as it is intended to be used in the system documentation. List the equipment, where it was tested, and whether it performs as outlined in the system documentation. Since these systems could be many different types of equipment, other verification items may be used to complete this test. A portable projector and screen should be tested under VP-108 Display Brightness Uniformity and VP-109 Projected Image Contrast Ratio.

Notes on Reporting

List any applicable verification items that apply to the accessory system or portable equipment, for example, "Ballroom audio system, 6 bodypack wireless transmitters, 6 wireless lapel microphones, and 6 sets of rechargeable batteries tested and stored in room 324 equipment rack microphone drawer."

Serviceability

Verification items within this category verify that the system is serviceable in conformance with the requirements provided within project documentation. Guidance is provided on all verification items listed in the Standard, which includes system accessibility, access panels, and rack clearance.

SERV-100 Access Panels

Verify that any access panels that have been installed to provide access to any type of AV equipment are properly sized and positioned as detailed in the project documentation.

Introduction

The project documentation provides locations for AV equipment or wiring in structural locations that require a service or access panel. Since access panel locations usually require coordination with the general contractor, the verification shall show that the equipment or wiring is in fact serviceable once the construction and installation are complete.

Tests, Procedures, and Equipment

Visually verify the following as pass/fail:

- Is the access panel located as specified in the drawings?
- Can buttons, wiring, status lights, panels, or other controls be easily accessed through the opening or door?
- Can connections be made to all jacks or connectors without obstruction?
- Is the access panel mounted plumb and level?
- If the enclosure holds equipment that may need to be replaced or removed for service, can it physically pass through the access panel opening?

Notes on Reporting

Final documentation shall consist of a copy of the elevation drawings with each access panel highlighted or checked to show that it has passed the verification. If the panel does not pass the verification, notes shall be made referencing the reason why the access panel has failed.

SERV-101 Ability to Maintain and Service Equipment

All equipment shall be accessible and capable of being maintained, serviced, cleaned or adjusted as necessary. All equipment requiring regular cleaning or maintenance shall be accessible without requirement for special equipment or tools that would disrupt the normal use of the facility and systems therein.

Introduction

This item is to verify that the placement of the equipment within the rack and/or within the space ensures adequate accessibility for future service and maintenance.

NOTE In many installations, the design needs to deal with equipment that is not readily accessible. In these circumstances, a maintenance access plan should be provided, detailing equipment and methods to gain access for maintenance.

Tests, Procedures, and Equipment

Mounted equipment should be accessible for services to be adjusted or replaced. Adjustment points on devices should be accessible. Equipment in plenum areas should be identified and accessible for service.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

SERV-102 Input and Output Panel Accessibility

Verify that all input and output panels are accessible and meet all requirements for user access and placement.

Introduction

The project documentation provides locations for input and output panels. This verification item checks those locations to ensure that the I/O panels are accessible and usable when installed. Where project documentation does not specify an exact location, usage scenarios shall be considered. The *2010 ADA (Americans with Disabilities Act) Standards for Accessible Design* shall be referenced in locations where applicable.

Tests, Procedures, and Equipment

Visually verify the following as pass/fail:

- Is the I/O panel located as specified in the drawings?

- For I/O panels located within an enclosure, can buttons or other controls be easily accessed through the opening or door?

- For I/O panels located within an enclosure, can connections be made to all jacks or connectors without obstruction? Each connector or jack shall be tested with the appropriate mating connector or cable for verification.

- Is the I/O panel mounted plumb and level?

Notes on Reporting

Final documentation shall consist of a copy of the elevation drawings with each I/O panel highlighted or checked to show that it has passed the verification. If the panel does not pass the verification, notes shall be made referencing the reason why the I/O panel has failed.

SERV-103 Rack Clearance

Verify rack placement and use for physical stability in accordance with the project documentation and regulatory authority.

Introduction

The placement of the rack and the manner in which it is used should ensure physical stability. Further, ensure the rack placement allows safe and complete working access for technicians to perform upgrades and on-going servicing of the system, as follows:

- Clearances around racks shall be in accordance with regulatory stands and codes as well as project documentation. Common clearance standards include:

  - TIA-569, *Pathways and Spaces*

  - AS/NZS 3084, *Telecommunications installations—Telecommunications pathways and spaces for commercial buildings*

  - UFC 3-580-01, *Telecommunications Building Cabling Systems Planning and Design* (US Department of Defense), item 2-5.7 ("36 in [900 mm] space both in front and in back of the rack, behind any installed equipment, and a minimum side clearance of 24 in [600 mm] on end racks")

  - BICSI standards

  - NEC/AS/NZS 3000 Safety Standards

- Moveable racks shall have their loads distributed properly to prevent them from tipping over while being moved. Further moveable racks should be used on a flat smooth surface and have a way to lock the mechanism to prevent movement.

- All stationary racks, either standalone or rack-cabinet combination units, are anchored according to the manufacturer's literature and project documentation

- All racks need to meet seismic requirements for geographic area and as required by the authority having jurisdiction (AHJ).

- All specialty rack-millwork/joinery/credenza combinations are installed in accordance with the manufacturer's instructions and secured in a safe and workable manner.

Tests, Procedures, and Equipment

Moveable Racks

Perform a visual inspection. Move racks in the intended manner and in the intended space and check safety straps where required.

Stationary Racks

Perform a visual inspection. Verify floor mounting hardware and check safety straps where required.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

Wireless

Verification items within this category verify that all aspects of wireless audio, video, and control systems perform and conform to the requirements provided within project documentation. Guidance is provided on all verification items listed in the Standard, which includes radio frequency, infrared, Bluetooth®, Digital Enhanced Cordless Telephony (DECT), and proprietary wireless systems.

WL-100 Wireless Audio Systems Operation

Verify that the operation of wireless audio systems (RF and IR) is as defined in the project documentation.

Introduction

Wireless audio systems are available in a number of different configurations, as follows:

- Combined with wireless video systems, where the audio is embedded
- Single source to a single zone
- Single source to multiple zones
- Multiple sources to multiple zones

These operate via a number of different types of protocols, including:

- 802.11 wireless Ethernet-based systems
- 802.11 wireless Ethernet mesh networks
- Apple AirPlay
- Digital Living Network Alliance (DLNA)

This item should verify that the following is provided:

- All audio devices defined in the project documentation are either natively compatible (through built-in support) or are paired with an appropriate transmitter and/or receiver.

- All mobile devices (e.g., smartphones and tablets) are natively compatible or installed with compatible applications.

- All servers are either natively compatible (through built-in support) or are paired with an appropriate transmitter.

- All transmitters and receivers are installed and powered.

- Remote management is installed and configurable for all devices.

- All supporting wireless networks are in place and transmitter-receiver pairs are assigned with IP addresses.

- All software, authentication and security are in place for each device.

Tests, Procedures, and Equipment

Each system should be tested independently. Following independent system verification, all wireless audio systems should be operated simultaneously to check for interference.

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale	
Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, it is recommended that a second level of testing is used to check:

- Maximum output level

- Total harmonic distortion + noise (THD+N)

- Frequency response

- Dynamic range (as defined by AES17: AES, *Standard method for digital audio engineering—Measurement of digital audio equipment*)

- Crosstalk

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

WL-101 Wireless Control Systems Operation

Verify that the operation of wireless control systems (RF and IR) is as defined in the project documentation.

Introduction

Wireless control systems provide mobility within a space to enable control from all locations as specified in the project documentation. Wireless control systems operate via a number of different types of protocols, as follows:a

- IEEE 802.11 wireless Ethernet-based systems

- IEEE 802.15.4 ZigBee

- IEEE 802.15.1 Bluetooth

- Apple AirPlay

- Wireless DMX—wireless lighting control

- Digital Living Network Alliance (DLNA)

This item should verify that the following is provided:

- Noise has been measured and factored.

- Bandwidth has been calculated and factored.

- Multiple systems can operate simultaneously.

- A channel scan has been performed to reveal which channels are available for use, noting the dynamic nature of this information.

- A review of gateway locations has been completed. Devices should not be near large metal objects, behind, under, or on top of metal objects, or any other place where interference could be an issue.

- All laptops are either natively compatible (through built-in support) or are paired with an appropriate transmitter.

- All mobile devices (e.g., smartphones and tablets) are natively compatible or installed with compatible applications.

- All transmitters and receivers are installed and powered.

- Receivers that are integrated with the corporate local area network to use the corporate wireless network have their internal wireless access points disabled.

- Remote management is installed and configurable for all devices.

- All supporting wireless networks are in place and transmitter-receiver pairs are assigned with IP addresses.

- All software, authentication and security are in place for each device.

Tests, Procedures, and Equipment

A site survey is highly recommended before systems are deployed to identify the channels available for use, interference, and signal propagation in relation to the space that will be covered by a specified number of transceivers. If any issues are detected, they should be brought up with the owner and the consultant so they could be immediate rectified.

Each system should be tested independently. Following an independent system verification, all wireless controls systems should be run simultaneously to check for interference. Typically, built-in tools provide signal strength and assist with the diagnosis of noise.

If issues are detected, a second level of testing using a spectrum analyzer is recommended.

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.

Check that all control signals are being received and all commands executed reliably with no intermittent control dropouts.

Notes on Reporting

Note as pass/fail. Note the configuration.

WL-102 Wireless Coordination

Verify that the environment is suitable for the required wireless services (RF and IR) to provide audio, video, and control, and can be implemented for the required number of channels as defined in the project documentation.

Introduction

The inclusion of wireless equipment (e.g., wireless microphones, wireless intercom, wireless interruptible foldback [IFB], or wireless personal monitoring systems) requires frequency coordination. This process takes into consideration active and future television stations for your region, other wireless frequencies already in use, governmental restrictions on allowable frequencies, and so on. Many times such coordination requires working closely with the wireless equipment manufacturer.

It is important to document all frequencies that are assigned to wireless microphones. The documentation can be referenced for future additions, service replacements, or coordination with rental or visiting systems. Taking the time to record this information is important because wireless equipment, including microphones and personal monitor systems, operate within a relatively small range of allowable frequencies. A successful operation of these systems often requires frequency coordination that covers the preexisting equipment.

Tests, Procedures, and Equipment

A spectrum analyzer capable of measuring the higher bandwidths required for computer displays can be expensive, so this type of test equipment is often rented to perform measurements for a specific project. Spectrum analyzers are also a good tool to sweep RF to

calculate bandwidth for a cable system or to sweep airborne RF to determine the available frequency bands for a wireless system.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

WL-103 Wireless Video Systems Operation

Verify that the operation of wireless video systems (RF and IR) is as defined in the project documentation.

Introduction

Wireless video systems are available in a number of different configurations, as follows:

- Single source to single display
- Single source to multiple displays
- Multiple sources to single display

These operate via a number of different types of protocols, including:

- 802.11 Wireless Ethernet-based systems
- Apple AirPlay
- Digital Living Network Alliance (DLNA)
- Intel Wireless Display (WiDi)
- Wireless HD
- Miracast

This item should verify that the following is provided:

- All display devices/projectors defined in the project documentation are either natively compatible (through built-in support) or are paired with an appropriate receiver.
- All laptops are either natively compatible (through built-in support) or are paired with an appropriate transmitter.
- All mobile devices (e.g., smartphones and tablets) are natively compatible or installed with compatible applications.
- All servers are either natively compatible (through built-in support) or are paired with an appropriate transmitter.
- All transmitters and receivers are installed and powered.
- Receivers that are integrated with the corporate local area network to use the corporate wireless network have their internal wireless access point disabled.
- Remote management is installed and configurable for all devices.
- Guest access USB dongles are located within the rooms for users.

- All supporting wireless networks are in place, and transmitter-receiver pairs are assigned with IP addresses.

- All software, authentication, and security are in place for each device.

Tests, Procedures, and Equipment

Each system should be tested independently. Following independent system verification, all wireless video systems should be operated simultaneously to check for interference.

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale	
Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using a spectrum analyzer is recommended.

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.

Notes on Reporting

A simple pass/fail reporting is all that is required by the Standard.

Appendix A: Sample Verification Report

Based on the outcome of the system's performance at each phase of the project, verification reports are issued to provide up-to-date verification information. The reports must acknowledge conformance to the Standard and include specific information described in the Standard, specifically:

1. Report header

   Example:

Project Name	
System Verifier	Report Date
Verification Phase	Issued to:

2. Project-specific verification items (please see sample test sheets [link] for format and content reference, as well as sample completed verification list [link] using I-Auditor)

3. List of verification items not verified on the project for the verification phased covered by the report

4. Signed acknowledgment of conformance with the Standard

   Example:

   The system verifier acknowledges that the performance of this audiovisual system has been verified in conformance with all required processes and contains all required elements as documented within INFOCOMM 10:2013, *Audiovisual Systems Performance Verification*.

   _____

   System Verifier   Date

Appendix B: Test Sheet Examples

Sample Audio System Performance Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AP-100
Verification Item	Emergency Muting	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that any required muting or operational change of the installed sound system(s) operates in accordance with local regulations in the event of a life safety or similar emergency.			
Inputs			
For all phases, first, identify requirements for muting assessed from project documentation, and then identify local regulatory codes. **Pre-Integration Phase:** No physical test is possible at this stage, but check to ensure that the control methodology and the necessary system inputs have been defined in the design. **Integration Phase:** Simulate the operation of the emergency system interface (e.g., by shorting out/opening the control system input). Audio system(s) must mute or provide required operational change (e.g., to allow the emergency signal to pass, if on a shared system). **Post-Integration Phase:** The emergency system should activate the operation of the identified emergency system interface to the AV system. Audio system(s) must mute or provide required operational change (e.g., to allow the emergency signal to pass, if on a shared system).			
Tests, Procedures, and Equipment			
Pre-Integration Phase: No physical test is possible at this stage, but the check is to ensure that the control methodology and the necessary system inputs have been defined in the design. **Integration Phase:** Simulate the operation of the emergency system interface (e.g., by shorting out/opening the control system input). Audio system(s) must mute or provide required operational change (e.g., to allow the emergency signal to be passed if on a shared system). **Post-Integration Phase:** Operation of identified emergency system interface to AV system—this should be activated by the emergency system itself. Audio system(s) must mute or provide required operational change (e.g., to allow the emergency signal to be passed if on a shared system).			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
This test should also account for systems whose operations or signal paths may be shared with an emergency system rather than simply treating the requirement as if the AV system is wholly independent.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-101
Verification Item	Loudspeaker Zoning	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Pre Integration ☐ Systems Integration		
Description			
Verify that loudspeaker zones are wired as defined in the project documentation.			
Inputs			
Different loudspeaker lines should be disconnected and relocated to different amplifier channels or amplifiers. Connections should be tested and complete. All loudspeakers should be checked to ensure they are in correct zones.			
Tests, Procedures, and Equipment			
Tests Audio test signal or audio program material should pass through individual loudspeaker lines. **Procedure** ▪ Set up a matrix router in the signal processor or a mixing console with multiple auxiliary outputs. ▪ Connect to various amplifiers powering up the loudspeaker lines. ▪ Pass audio test signal or program audio material through each line individually. ▪ Check if the audio is coming through one individual loudspeaker line or it is getting mixed with other lines. **Equipment** ▪ Audio source ▪ Mixing console or open architecture digital signal processor (DSP) ▪ Amplifier ▪ Wired loudspeakers			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-102
Verification Item	Alignment of Multiple Audio Source Levels	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify calibration of permanent audio system inputs such that the difference between any input signal level after the first common gain adjustment meets the requirements of the project documentation. This verification item should require a metric to be verified.

Inputs
▪ Determine the common signal level within the system after the first common gain adjustment (typically, the pre-amplifier gain). On an analog or digital mixer, it is typically 0 dBu. On a DSP system, consider referencing the meter's "top of the green section" or determining some other level that gives adequate headroom like −15 dBFS. ▪ Check each source at the first gain adjustment to ensure that levels match. ▪ Introduce each source in turn at its nominal operating level to the input of the system. ▪ Adjust the mixer input until the desired common signal level is measured at the output of the channel strip. Use pre-fade listen metering, channel metering, or output metering with the channel fader and output faders set to 0 dB.

Tests, Procedures, and Equipment
Verify levels via audio DSP or analog system level meters. Confirm that the levels are as specified in the system documentation. Ensure there is no: ▪ Hiss or hum from the loudspeakers when there is no signal distributed ▪ Overdriving distortion when the system is running at nominal operating levels

Metrics
A typical system produces no more than a 1 dB variance in program source levels, when each program source is playing a calibrated media. However, this may vary between systems and should be specified in the system documentation.

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes
Any anomalies should be noted with specific reference to the active inputs and outputs in the system at the time of the testing. Specific levels should be noted at each adjustment point.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-103
Verification Item	Audio Buzz and Rattles	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that no audible noise caused by improper installation of any equipment provided in completed system(s) is present.			
Inputs			
All installation and programming activity should be completed before the test is started.			
Tests, Procedures, and Equipment			

Rattle Noise
Using a continuous sweep signal as an input to the sound system(s) operating at the level of 3 dB below the onset of distortion , monitor for any undesired acoustically induced noise (i.e., low frequency speaker output causing a loosely fitting grill to vibrate causing an audible harmonic distortion).

Buzz Noise
With all AV equipment on but with no content playback, verify to ensure no condition is causing noise within the audio system (i.e., an unbalanced input picks up, and amplifies a stray RFI/EMI signal that produces audible buzz). Again, the audio level setting should be at level 3 dB below the onset of distortion.
Each speaker should be verified individually.

Metrics
N/A
Outputs
☐ Pass ☐ Fail
Measurement Result:
Notes
Note items for rectification.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-104
Verification Item	Audio Routes	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that all audio routes are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and routing as defined in the project documentation.

Inputs
All audio wiring is installed, labeled, and terminated.

Tests, Procedures, and Equipment
Provide a test signal at each input location and verify that the signal is present at the output of the associated wire. A spreadsheet noting each cable with a respective cable label should be used to track that each cable is tested. For balanced connections, a common XLR cable test device can be used with various adapters to verify that the polarity of the cable is correct. An example unit would be the Whirlwind MCT-7 for a basic cable test unit or the Galaxy Audio Cricket for a kit that has a send and receive unit. These and similar units have LEDs to show that there is continuity between all terminated pins.

Metrics
N/A

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes
Provide a spreadsheet with each cable identified and showing if it has passed the test.

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AP-105
Verification Item	Reverberation Time	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify reverberation time meets the requirement defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
The audio system is installed in a room.

Tests, Procedures, and Equipment
Use an impulse noise test to determine the reverberation time within a room.
The impulse noise test is routinely performed using an impulse noise source such as a balloon and a reverberation time meter. The balloon is popped and the meter provides an instantaneous result. The impulse must be sufficient to produce an impulse of 40 dB above the background noise level in the room.
The procedure for measurement of reverberation time shall comply with BS EN ISO 3382-2:2008 or AS/NZS 2460, depending on location.

Metrics
Metric selection should include the type of room based on the recommendations from the international acoustics standards and manufacturers' documentation. Particular attention should be paid to rooms with videoconferencing.

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes
In the reporting, include the following:
▪ Volume of the room in cubic meters or equivalent cubic feet, depending on location
▪ Record reverberation time by frequency in milliseconds (ms)
▪ For auditoriums, note the number of seats in the room
▪ Note the position of variable items such as blinds and curtains
▪ Type and position of impulse source used
For larger auditoriums and performance venues, it is recommended to refer to the referenced standards for the full list of procedures and reporting items.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-106
Verification Item	DSP Programming	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that all DSP-based products have been programmed as defined in the project documentation.

Inputs
The programming has been received from the source and uploaded to the DSP system.

Tests, Procedures, and Equipment
Verify the DSP system has the most current applicable firmware installed.
Verify inputs/outputs are routed to the proper area within the program.
Verify all necessary adjusting functions (i.e., volume levels, EQ levels, video level adjustments) are in place and seem logical.

Metrics
N/A

Outputs
☐ Pass ☐ Fail
Measurement Result:
Prepare notes to the programmer about the items not functioning properly and any modifications to the original program.

Notes
This area can be very complex or as simple as assuring the default setting in the DSP is set. It is important during the staging and checkout that all modifications to the original program have been clearly documented and communicated to all appropriate members of the integration team.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-107
Verification Item	Loudspeaker Physical Alignment	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that loudspeakers are placed and aimed as defined in the project documentation.			
Inputs			
All audio wiring is installed, labeled, and terminated. All loudspeakers are installed and operational.			
Tests, Procedures, and Equipment			
Check that the loudspeakers are mounted in the location specified, at the correct height, and with the proper vertical and horizontal aiming. Project documentation should show the physical placement and aiming information of the loudspeakers in the project. In the case of program loudspeakers, whether a single speaker or cluster, the documentation shall list height, horizontal, and vertical angle. For line arrays, the physical location and aiming of the top box in the array shall be followed by the inter-box angle of the other loudspeakers in the array. Once that it's been confirmed that the loudspeakers are aimed per project documentation, proceed to AP 114 Audio Coverage in Listener Areas to verify coverage uniformity.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result: Provide a spreadsheet of loudspeaker locations. Alternatively, provide a shop drawing or plan view with each loudspeaker location.			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AP-108
Verification Item	Loudspeaker Polarity	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that all loudspeakers have correct polarity as defined in the project documentation.			
Inputs			
The complete audio chain, from input (microphone, audio source) to output (loudspeaker) should be connected. Polarity can reverse at any point in the signal chain; therefore, it is very important to complete a polarity test after the complete audio chain is wired/connected.			
Tests, Procedures, and Equipment			
Tests A loudspeaker polarity check **Procedures** A standard polarity tester set contains two devices: a generator and a detector. An impulse tone is injected as an input to the audio chain, and the detector is placed in front of the loudspeaker. Indicators on the detector unit show whether the polarity is normal or inverted. Each loudspeaker in a multi-way configuration should be tested separately. **Equipment** A complete audio chain, a polarity generator, and a polarity detector			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result: Polarity is normal or inverted			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-109
Verification Item	Loudspeaker Time Alignment	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that loudspeaker time alignment performs as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
Systems Integration Phase: With system construction completed, install all the loudspeakers at appropriate location as per project documentation drawings and provide correct amplification as per the connection diagram as shown in the project documentation **Post-Integration Phase:** With sound system commissioned, loudspeakers are powered by correct amplifier channels and DSP outputs are configured per design. Sound system should have also passed through the AV performance tests AP106 DSP Programming, AP107 Loudspeaker Physical Alignment and AP114 Audio Coverage in Listener Areas.

Tests, Procedures, and Equipment
Tests ▪ Audio test source—A pink noise generator or sine wave sweep generator ▪ Sound analyzer device—Many devices and software packages are available (e.g., SIA Smaart, EASE RA, TEF, various tablet apps, NTi Minilyzer, NTi XL2, Bruel & Kjaer devices). A measurement device shall display a 20 Hz-to-20 kHz spectrum of audio in dB SPL at a minimum of 1/12 octave bands. A dual channel system capable of comparing a test stimulus audio source to a reference microphone input is preferred. ▪ Pre-amplifier/input device—Most real time analyzers (RTAs) today are software based. A quality microphone pre-amplifier/input device is required to transfer the audio from the microphone to the computer or tablet device running the software (e.g., Sound Devices USBPre 2). **Procedure** ▪ Route the signal to an input of the system using a pink noise generator and matching the input sensitivity to achieve a unity gain signal. ▪ Route the signal to the test software or RTA device (if it is a two-channel device that can show the difference between the test signal and the signal after routing through the system). ▪ Connect an output of the system (line level or microphone level) to the test software or RTA device. If an output such as a record output is not available, use the final output device before the amplifier. ▪ Unmute single loudspeaker stack and measure the distance in delay locator or impulse response window of the software. ▪ Repeat the same procedure for the second loudspeaker stack and mute the primary loudspeaker stack. The difference between two time arrivals is 19.47 ms and meets the time delay required for the secondary stack for absolute time alignment.

Metrics
Best-case metrics for correct time alignment is 20 ms behind the main sound source. Maximum accepted range of time for alignment is 25 to 35 ms.

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-110
Verification Item	Audio System Phantom Power	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that phantom power is provided at the correct voltage and correct locations as defined in the project documentation.			
Inputs			
At the system input, verify voltages between the ground and audio pins of the balanced audio connection. This voltage is necessary to power condenser-type microphones.			
Tests, Procedures, and Equipment			
For an XLR3 connector, using a multimeter set for DC voltage, measure between pins 1 and 2 and pins 1 and 3. The voltages should have the same readings.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			
Standard IEC 61938 P12 Phantom power application on balanced connectors Standard IEC 61938 P24 Standard IEC 61938 P48			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-111
Verification Item	Loudspeaker Transformer Tap Setting	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio Performance		
Verification Phases	☐ Systems Integration		
Description			
Verify the loudspeaker transformer tap setting in constant voltage systems is as defined in the project documentation.			
Inputs			
Loudspeakers have been installed.			
Tests, Procedures, and Equipment			
Verify the loudspeaker system by calculating the predicted impedance and then using an impedance meter to check the line. This will verify two things: ▪ All loudspeakers are connected. ▪ All loudspeakers are tapped correctly. If your impedance checks out, you don't have to manually verify the tap and wiring on each loudspeaker.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-112
Verification Item	Acoustical Ambient Noise	Date of Verification	
Verifier			
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the background acoustic noise levels within AV spaces are within the required limits as detailed in the project documentation. This test is specifically related to ambient noise levels and not audio system quiescent noise, which is tested separately. This verification item shall require a metric to be verified.

Inputs
Air conditioning operating normally. All associated building plant in the vicinity operating normally. Background noise level requirements determined from project documentation. The sound system is switched off.

Tests, Procedures, and Equipment
The room to be tested should be set up as follows: ▪ HVAC is operating normally. All associated building plants in the vicinity are operating normally. ▪ Windows and doors are open or closed. ▪ Neighboring spaces in the building are occupied with normal activities in operation. ▪ Background noise level requirements are determined from project documentation. ▪ Sound system is switched off. ▪ In situations where traffic (or other) noise levels may vary widely over a 24-hour period, measurements to assess compliance should be taken at the relevant time according to the area of occupancy or activity in the building. ▪ Measurement of background noise can be undertaken using a sound pressure level (SPL) meter/spectrum analyzer to determine background noise levels dB A and/or NC and NR rating, as required. Measurements need to be made throughout the space. ▪ When using a sound pressure level meter, make sure the meter is set to A-weighted and Slow response. ▪ The measuring instrument should be used in accordance with AS 2659, *Guide to the Use of Sound Measuring Equipment*, and sound level meters should be in compliance with IEC 60804/BS EN 60804/AS 1259.2.

Metrics
Specify the maximum background noise limits to the architect, other consultants on the project and the owner. When the project design goal for maximum acoustical ambient noise is not stated or known, the professional who performs the testing should consider the tables below. The actual metric selection should include and compare the type and use of the room with the recommendations within the international acoustics standards and manufacturer documentation. Particular attention should be paid to rooms that will incorporate videoconferencing.

Outputs
☐ Pass ☐ Fail Record tests and their locations. The output could be in the form of a space map with noise levels or a tabulated list of measurements against grid positions. Pass/fail statement and any indication of likely sources of noise that may need to be addressed.

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-113
Verification Item	Assistive Listening Devices	**Date of Verification**	
Verifier			
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that all devices that are part of the assistive listening system have been tested as a complete end-to-end personal listening system. Verify that the assistive listening system complies with regulatory requirements and adheres to project documentation. This verification item should require a metric to be verified.

Inputs
This item requires design documentation and that the main house audio system and the ALS have been fully installed and set up/adjusted according to any applicable codes/standards (i.e., ADA in USA).

Tests, Procedures, and Equipment
A comprehensive test procedure for this item is detailed in AS 1428.5-2010. Some of the subjects and issues in the Standard are listed below. For complete details on testing, the Standard will need to be obtained.

Induction Loop Systems
- Frequency response
- Distortion
- Compressor/AGC or equivalent
- Power source
- Min/max magnetic field strength
- Background magnetic field strength
- Functional testing
- Loop receiver

Modulated Radio Systems
- Frequency response
- Distortion
- Compressor/AGC or equivalent
- Power source
- Receiver and accessories
- Signal-to-noise ratio
- Signage

Infrared Systems
- Frequency response
- Distortion
- Compressor/AGC or equivalent
- Power source
- Receiver and accessories
- Signal-to-noise ratio
- Signage

Metrics
Metrics for an audio induction loop system should be based on a regional standard, such as IEC 60118.4, as follows:
- Magnetic field strength at the listening height must be 400 mA/m (RMS) +/– 3 dB.
- Variation of field strength across the listening plane must not change by more than +/– 3 dB.
- Frequency response of the system must be within +/– 3 dB of the level at 1 kHz from 100 Hz to 5 kHz.
- Background magnetic noise over the listening volume should be no worse than –47 dB(A). However, a background magnetic noise level no worse than –32 dB(A) is acceptable.

For IR- and FM-based systems, the following should apply:
- Refer to the manufacturer's requirements for signal strength in the various frequency bands of operation.
- In some countries, licensing is required for operation of FM systems (e.g., in the United Kingdom for systems operating between 175.100 and 177.150 MHz). |

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-114
Verification Item	Audio Coverage in Listener Areas	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that coverage of the audio systems in listener areas meets the performance requirements as defined in the project documentation. ANSI/INFOCOMM 1M-2009, *Audio Coverage Uniformity in Enclosed Listener Areas*, should be used. Perform separate tests for all independent systems within the project, including but not limited to program sound, speech reinforcement and show relay.

Inputs
The complete audio system should be commissioned and should have followed and confirmed with several other audio performance tests.

Tests, Procedures, and Equipment
Follow the test procedures as listed in ANSI/INFOCOMM 1M-2009, depending on the type of application.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Obtain a copy of the ANSI/INFOCOMM 1M-2009 standard from InfoComm. Follow the tests and procedures listed in the 1M standard.

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AP-115
Verification Item	Audio Dynamics	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		
Description			
Verify use of audio dynamics, including but not limited to noise compensation, automatic gain control, gating, feedback suppression, compression, limiting, delays, and levelers meets the requirements defined in the project documentation.			
Inputs			
Visual inspection of input and output gains for any processor or DSP block that affects dynamics in the system by some automatic method.			
Tests, Procedures, and Equipment			
After the gain structure has been set and adjustments for microphone placement completed as required in project documentation, check each dynamics block or piece of hardware. Identify proper input and output gain for each block. Specifically check for clipping at each input and output stage. For gating mixers (DSP or hardware), check that the threshold of the gate is set to allow for the prescribed use of the system, with no muting of desirable audio. Properly setting limiters involves many factors. However, by running the systems at levels indicated in the project documentation, no clipping should be present at any stage. Increase system gain to the point where clipping begins at the output stage of the device to the amplifiers, or at the amplifiers. The limiter thresholds should be set slightly lower than this point to prevent the amplifiers and output stages of the processor or DSP from clipping.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			
Final DSP files shall be delivered to the customer with proper dynamics settings. Note any major dynamics issues and changes to settings in the submittal report.			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-116
Verification Item	Audio Level Exceeds Background Noise Level	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the audio level provided by the installed audio system exceeds the background noise level as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
Target speech and program levels identified in system specifications.

Tests, Procedures, and Equipment
Ensure that measurement locations are the same as the measurement locations used in the AP-112 Acoustical Ambient Noise, so the two measurements are aligned by location. InfoComm's course *Elements of Setup and Verification Online* explains how to measure an AV system's sound pressure level.

Metrics
The audio system designer should state how much the audio level should exceed the background noise level. This determination may be based on the venue and the audio content. When it is not known or stated as a project design goal how much the audio level should exceed the background noise level, the professional who performs the testing may use the following metrics to form a pass/fail judgment. ▪ 15 dB S/N is the recommended minimum for spaces where the background noise is 35 dB SPL A-wtd. ▪ 25 dB S/N is an InfoComm International best practice. **NOTE** Generally, a good target for overall sound pressure level is 25 dB above the ambient noise level. Blindly setting a sound system for 25 dB above ambient noise where ambient noise is higher can produce a system that is excessively loud and intelligibility will drop (i.e., if the sound is too loud, people will experience fatigue and become distracted).

Outputs
Record the locations of each test position. Output could be in the form of a grid map with noise levels or a tabulated list of measurements against grid positions. A pass/fail statement and any indication of type of failure (e.g., audio system performance or room acoustical ambient noise problem) should be created.

Notes
The difference between the audio level and the background noise is a ratio and should be recorded in decibels.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-117
Verification Item	Playback Source Frequency Response	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the electronic frequency response of the audio system is as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
Audio system is capable of passing audio from source to speaker. Room/environment conditions closely match finished condition. System gain settings are properly calibrated.

Tests, Procedures, and Equipment
Test
1. Using a pink noise generator, route the signal to a system input, matching the input sensitivity to achieve a unity gain signal.
2. Route the signal to the test software or RTA device (if it is a two-channel device that can show the difference between the test signal and the signal after routing through the system).
3. Connect a system output (line level or microphone level) to the test software or RTA device. If an output such as a record output is not available, use the final output device before the amplifier.
4. When viewing the difference between the two signals as a graph (transfer function), the frequency response should show a flat (+/– 0.5 dB) 20 Hz-to-20 kHz response curve.
To achieve an accurate test, any input equalization, high-pass filters, compression, or auto-gain processing should be bypassed. Output EQ, filters, compression, limiting, and bandpass gain or crossovers should be bypassed as well.
Refer to RaneNote 145 for an alternate testing method using a sine wave generator and a voltmeter.
Equipment
▪ Audio test source
▪ Sound analyzer device
▪ Pre-amplifier/input device

Metrics
Basic hearing frequency response has produced an industry standard of 20 Hz to 20 kHz for full-range audio equipment. In the absence of a design specification, use 20 Hz to 20 kHz. A sample statement to use is, "The system under test shall produce a flat frequency response (+/– 0.5 dB) from 20 Hz to 20 kHz."

Outputs
Frequency Response +/– 0.5 dB
☐ Design Specification: ___ Hz to ___ kHz
Measured Result ___ Hz to ___ kHz
☐ Pass ☐ Fail
In Absence of Design Specification
20 Hz–20 kHz +/– 0.5 dB
Measured Result ___ Hz to ___ kHz
☐ Pass ☐ Fail

Notes
During testing, the design specification and the measured results should be recorded. The pass/fail status should also be documented.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-118
Verification Item	Audio System Equalization for Spectral Balance	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the audio system equalization is in accordance with the acoustic response curves as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
Audio system is capable of passing audio from source to speaker. Room/environment conditions closely match finished condition. System gain settings are properly calibrated.

Tests, Procedures, and Equipment
Frequency response measured as +/– 0.5 dB based on the Hz requirement of the system. **Equipment:** Microphone designed for audio measurement, SPL calibration device, RTA hardware or software (may require audio preamp for the microphone to interface with the RTA hardware/software)

Metrics
The system shall produce a frequency response of +/– 0.5dB based on the required range of the system. In the absence of project documentation, the frequency response shall be 20 Hz to 20 kHz, 50 Hz to 16 kHz, or 100 Hz to 14 kHz.

Outputs
Frequency Response +/– 0.5 dB ☐ Design Specification: ___ Hz to ___ kHz Measured Result ___ Hz to ___ kHz ☐ Pass ☐ Fail **In Absence of Design Specification** ▪ 20 Hz to 20 kHz ▪ 50 Hz to 16 kHz ▪ 100 Hz to 14 kHz Measured Result ___ Hz to ___ kHz ☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AP-119
Verification Item	Audio System Latency	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that audio system latency meets requirements defined in the project documentation.

Inputs
Click or other fast transient noise source

Tests, Procedures, and Equipment
Tests
Oscilloscope with trace at system input and system output and software program
Equipment
Oscilloscope and audio test generator

Metrics
With Video Lip Sync
Undetected: +20 ms (advanced) and −40 ms (delayed)
Slightly noticeable: +40ms (advanced) and −60ms (delayed)
Noticeable: +60 ms (advanced) and −160 ms (delayed)
Acceptable window: +90 ms (advanced) and −185ms (delayed)
Audio-Only Monitoring of Live System Performance
Undetected: 1.2–2 ms
Slightly noticeable: 2–5 ms
Noticeable: 5–10 ms
Acceptable window: <10ms

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-120
Verification Item	Audio System Speech Reproduction at Listener Positions	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the audio system provides speech reproduction (intelligibility) as defined in the project documentation. This verification item should require a metric to be verified.

Inputs
Installed audio systems should provide an adequate level of intelligibility as a basic requirement for effective oral communication. The most effective way to test to confirm that an installed system meets ineligibility requirements is to measure the speech transmission index (STI).

Tests, Procedures, and Equipment
Testing shall be performed in accordance with IEC 60268-16, Notes on Reporting, and/or ANSI S3.5-1997.   The test should be conducted in a completely finished space with the system in complete working order.   Tests should be conducted with an audio analyzer device such as an NTi Audio XL2 STI-PA MR-PROTest signal generator or approved equivalent. A detailed report should be provided with the following content: ▪ Indicate metric minimum STI-PA selection based on application and as identified in the project documentation.   ▪ Identify listener areas and determine each sample listening/testing location   ▪ Document the locations and placement of the test microphone, speakers, and tests results for each sample listening location using detailed building plans.   ▪ Document room temperature and humidity.   ▪ Document room finishes and applied acoustical treatment.

Metrics
Objective rating of speech intelligibility by speech transmission index, which provides recommended STI rating for various applications.

Outputs
☐ Pass ☐ Fail   Measurement Result:

Notes

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Project Name		Verification Item #	AP-121
Verification Item	Audio System Total Harmonic Distortion	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the total harmonic distortion of the installed audio system is as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
This item measures the capability of an audio system to accurately reproduce content after passing through a single device or entire signal path without introducing any unwanted distortion. High levels of harmonic distortion will help reveal faulty equipment and improper gain structures. Audio harmonic distortion is a measurement of the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. It is possible to measure the full 20 Hz-to-20 kHz range using a sweep.

Tests, Procedures, and Equipment
1. Use an audio test generator to produce a 1 kHz sine wave at the input of a device or system.
2. Perform a spectral analysis on this signal (using a spectrum, or Fast Fourier Transform [FFT] analyzer) examining the output for evidence of any frequencies other than the one applied.
3. In addition to the original input sine wave, if there are frequencies arriving at harmonic intervals of the input frequency (i.e., 2x, 3x, 4x, 5x, 6x, 7x, 8x), a metric can be derived.
4. Using a spectrum analyzer to obtain the level of each harmonic, perform a root mean square (RMS) summation. This can usually be done automatically with more advanced test equipment.
The level is divided by the fundamental level and cited as the total harmonic distortion percentage.

Metrics
Less than 1% is considered high fidelity.

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AP-122
Verification Item	Conferencing Audio Levels	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that in a conferencing audio application, the incoming and outgoing audio levels are checked and adjusted in the system as defined in the project documentation. This verification item should require a metric to be verified.

Inputs
This item measures the power or amplitude ratio of an audio signal to noise after passing through a single device or entire signal path. The system or device is typically measured with no signal present (noise) and then again with a defined signal level and bandwidth (signal). The signal is generally a 1kHz +4 dBu (IEC 60268-17) or 1 kHz 0 dBu signal, with measurements taken at the same location within a system. A simple RMS multimeter is suitable for taking measurements.

Tests, Procedures, and Equipment
A standard reference point should be used to calibrate audioconference levels arriving in the room or being sent from it. An audio signal coming from the far side should feed to the audio or video codec. A far-side signal should include a playback of an audio tone (pink noise) and human voice transmitted at 0 dB as referenced within the audio digital system processing (DSP) system and/or codec to aid in level adjustment. The reference point should also contain a method to measure the signal being sent from the local room.
Each system should then be adjusted fully to local specifications found in other areas of the verification standard, such as AP-114 Audio Coverage in Listener Areas. Each additional room within an enterprise-wide conferencing system should call in to the same reference point to receive the far-side signal and adjust accordingly.
The incoming far-side signal should be adjusted to 0 dB, as referenced within the audio DSP system and/or codec from a standard test site. All uses of that audio signal would then be adjusted as required by local in-room tests. All inputs to the system (e.g., microphones and other sources) should be adjusted to achieve 0 dB, as referenced at the output of the audio DSP system. The outgoing audio should be adjusted to 0 dB, as referenced in the audio DSP and/or codec and verified by the same standard test site.

Metrics
The system designer should investigate if the organization using the conference facilities utilizes a standard adjustment site or specific audio settings. Reference to this site should be made available to the integrator setting up the room. In the absence of a reference site, use a VTCTest produced by Gary Miyakawa (http://vtctest.pointsofdata.com): Dial string: 71.14.2.157 The VTCTest checks audio and video in both directions. It also checks for H.239 (dual video) and offers a callback test.

Outputs
☐ Pass ☐ Fail
Documentation to verify testing procedures and readings observed to be included in system verification reports.

Notes
The project team should determine the standard reference test site.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-123
Verification Item	Conferencing Echo Suppression Performance	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that a system with conferencing capability performs at nominal operating levels in a full duplex mode with echo and latency performance as defined in the project documentation.

Inputs
Inputs into the testing include: ▪ Audio used in a reference signal should be post-process audio. The cancellation reference should be a sample of the signal being sent to the power amplifiers. ▪ Avoid routing far-end audio through dynamic feedback controllers. This could give a false acoustic picture of the room to the AEC. ▪ As the audio signal is acquired from a microphone, assure the AEC function is completed prior to any automatic gain control, noise canceling, muting, or microphone mixing. Applying any of these functions prior to the AEC activity could cause a false acoustic picture of the room. ▪ Ensure that the AEC has a strong signal of the incoming audio as a reference. An incoming signal that is weak could cause the AEC to miss elements that should be eliminated from the outgoing signal.

Tests, Procedures, and Equipment
Testing for AEC operation is best performed on a hard-wired telephone handset calling from outside (far-side) of the integrated room being evaluated. Using a handset is preferred because it allows a better detection of anomalies. Mobile handsets could introduce elements that would confuse the results and should not be used for this testing. A wideband signal is also preferred to detect anomalies in all frequencies. If the system cannot call in from a wideband telephone system, a video call can be made using a headset. Place a call into the room being tested from a far-side system. Far-side participants should be able to speak at various levels without hearing their voices echo back through the call. Additional testing should include both sides speaking at the same time to gauge the echo canceller's full-duplex performance.

Metrics
In practical terms, no amount of perceptible acoustic echo is acceptable from an installed room system. The AEC will work to digitally eliminate any elements of the reference audio signal from the outgoing audio signal. In technical terms, some acoustically difficult rooms may cause acoustic echo to be present for short periods of time as the acoustics of the room change (people move or doors open and close) and the AEC must adapt. Metrics may be developed to determine amounts of acoustic echo that may be allowed during this adaptation stage. In any case, this effect should not remain perceptible (less than 55 dB of cancellation) for more than 200 ms during full-duplex operation (i.e., both sides speaking simultaneously).

Outputs
☐ Pass ☐ Fail

Notes
Note any acoustic echo anomalies with specific reference to parameters in which the echo occurs. It is essential to know which far-side signal was affected (video, telephony) and through which microphones.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-124
Verification Item	Loudspeaker Impedance	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that all loudspeaker circuits have the correct impedance as defined in the project documentation. This verification item should require a metric to be verified.

Inputs
Testing a loudspeaker for the proper impedance can reveal wiring issues or problems within the loudspeaker itself before connecting amplifiers. Catching impedance issues before running sound to the loudspeakers can prevent damage to the amplifier or loudspeakers. It is important to consult the system documentation for the expected impedance characteristics of the system under test.

Tests, Procedures, and Equipment
First, calculate the expected impedance of the system.

Using an impedance testing device specifically designed for loudspeaker systems, test each loudspeaker cable at the amplifier by first removing the loudspeaker cable from the amplifier outputs. Recommended test devices include the GoldLine ZM series of test units and the TOA ZM-104A. The GoldLine unit produces test tones at 100 Hz, 330 Hz, 1 kHz, and 10 kHz, allowing the testing of elements within a multi-driver loudspeaker.

Follow these steps to perform the measurement:

1. Disconnect the wires from the amplifier.
2. Calibrate the meter:
3. Connect meter leads at the first loudspeaker. Connect one lead to each wire on the first loudspeaker in the chain (polarity is not important).
4. Observe the reading and compare it with the expected reading. It should be similar to the predicted impedance. A tone should be heard through the loudspeakers that are being measured. Hearing the tone is a good indicator that, overall, the wiring is good.
5. Reconnect the loudspeaker wires and power on the amplifier.

When working with large systems, check the line impedance often. Do not wait until all of the loudspeakers are wired and the scaffold is down to find out that one of the loudspeakers is bad. As you install a group of loudspeakers, test it to make sure there are no problems before you install the next group. Write down the final measured impedance, which will be very useful for future system service and maintenance.

Metrics
The metric depends on the design. The example given reflects a particular combination of amplifier power, voltage, and number of speakers. Since this is different in every design, the metric is that the measured impedance isn't below the calculated impedance.

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes
Create a spreadsheet listing each loudspeaker cable by wire number and system, the resultant impedance measurement, and the test frequency. Note any impedance measurements that fall outside the expected range presented in the system documentation.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-125
Verification Item	Microphone Physical Alignment and Placement	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify proper alignment and placement of microphones in the system as defined in the project documentation.

Inputs
All audio wiring is installed, labeled and terminated. Microphones are installed. The system can pass audio from microphones to the loudspeakers or other destination (e.g., far end of an audioconference).

Tests, Procedures, and Equipment
No specific tests are required. Check pickup patterns and locations against the system specifications. Ensure handheld, lavalier, wireless, and other non-fixed microphones in the system are provided and tested.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Provide a spreadsheet of microphone locations and check each as pass or fail. Alternatively, provide a shop drawing or plan view with each microphone location referenced as pass or fail.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-126
Verification Item	Microphone Gain Before Feedback	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the speech reinforcement system is operating without feedback and at audio levels as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
The audio system is installed and functional.

Tests, Procedures, and Equipment
Set a microphone in the space where it will normally be used. Unmute the microphone and set it to produce a sound level in the audience area based on the system documentation. The system documentation should also indicate the required headroom of the system beyond the normal use setting. Connect a pink noise source into the room and play it back in the audience at a level equal to the necessary microphone dB level. Upon muting the pink noise, no additional feedback or ringing shall be detected. Unmute the noise source and raise the level at 3-dB increments, muting each time to determine if feedback is present.

Metrics
When feedback is detected, a spectrum analyzer should reveal the specific frequency. This frequency may be attenuated with a filter to raise the microphone headroom before feedback. At some point, adding too many filters really just results in lowering the microphone gain. So, this should only be done sparingly. If the system is normally used with multiple microphones or a wireless microphone that could be placed in many locations, run a test accounting for those variables. Generally, each doubling of the number of open microphones at any one time reduces the system headroom by 3 dB.

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes
List the headroom in dB above the standard operating volume at which feedback occurs. Alternately, list the maximum sound pressure level generated in the listening area before feedback.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-127
Verification Item	Microphone Level Alignment	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify calibration of microphone inputs so that the difference between any input signal level after the first common gain adjustment meets the requirements of the project documentation. This verification item should require a metric to be verified.

Inputs
Connections to microphones are in place and tested. Microphone should be connected to a mixing console or DSP unit.

Tests, Procedures, and Equipment
Tests Microphones should be connected to either one of the signal processing units, similar to mixing consoles or a DSP. Each channel should have individual pre-amplifier gain control to adjust the incoming signal level. The input on the signal level meter should read 0 dBu to match all microphone levels. **Procedures** A person should stand at 1 m (3.3 ft) from each talker position in the room. Each person should be made to talk at about 60 dB SPL into each microphone. Adjust the settings on the pre-amplifier gain controls to produce a 0-dB level at the input of the mixer bus. **Equipment** The testing equipment shall consist of: ▪ Microphones that are normally used in the space. ▪ DSP or mixing consoles with individual mixer channels. It is also critical to have a person who can talk at the same pace and same pitch.

Metrics
The best case is 0 dBu level for each microphone. The maximum allowed range is +/– 1 dB variation. It may vary based on the type of equipment and the meter scale.

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes
All applicable microphones should have similar characteristics (e.g., polar pattern). Physical inspection for any defects should be completed. The automatic gain control (AGC) feature, found in many DSPs, should be disabled. These tests are performed at the input signals and should not be verified by listening through loudspeakers.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-128
Verification Item	Multi-channel Loudspeaker System Output	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the audio outputs of a multi-channel loudspeaker system are assigned correctly to designated outputs as defined in the project documentation.

Inputs
Speakers are installed and wiring is terminated. Receiver is in place or the appropriate DSP/processor/amplifiers are set up to pass audio to the appropriate outputs.

Tests, Procedures, and Equipment
Many surround-sound receivers and processors (application 1) have built-in test generators that cycle a test tone through each output of the device. A number of test DVDs exist with audio routed to each specific output and can also be used to test. If a DSP unit is involved, test tones can easily be routed to each speaker.
For application 2, the best method is to play a tone within the appropriate passband of the driver under test through the system while muting all other outputs. Using a multimeter, verify that the speaker wire for the driver under test has the test tone. Running a 1K tone to a miswired line that delivers it to a woofer instead of a mid-range driver would still produce a tone and, in such a case, a casual ear test would be misleading.

Metrics
N/A

Outputs
☐ Pass ☐ Fail
Provide a spreadsheet identifying each loudspeaker or driver and reporting whether they passed the test.

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-129
Verification Item	Sound Masking	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that audio system sound-pressure levels and equalization are adjusted to the level of sound masking as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
Reference source and spectrum analyzer

Tests, Procedures, and Equipment
1. Perform a spectral analysis within the space (using a spectrum or Fast Fourier Transform [FFT] analyzer) examining the background noise for a 30-s minimum, with no other noise sources present or generated.
2. Use an audio test generator, amplifier, and loudspeaker to produce broadband pink noise or simulated speech into a space at referenced levels in dB.
3. Perform a spectral analysis within the space (using a spectrum or FFT analyzer), examining the source noise for a 30-s minimum.

Metrics	
Articulation index: Confidential (0.00–0.05) Normal (0.05–0.20) Marginal (0.20–0.30) None (0.30–1.00)	**Privacy index:** Confidential (95–100%) Normal (80–95%) Marginal (70–80%) None (0–70%)

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes
When reporting on this item, include the following elements: ▪ Facility location ▪ Identification of the acoustic instrumentation (manufacturer, model, and serial number) and the last calibration date ▪ Names of the persons conducting the measurements ▪ Date and time of each measurement

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-130
Verification Item	Audio Reinforcement System Headroom	Date of Verification	
Verifier		Version	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the audio system is capable of performing above nominal operating levels without distortion as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
Target speech levels identified in system specifications.

Tests, Procedures, and Equipment
Using a sound meter (dB-SPL, A-wtd, slow):   ▪ Refer to system target speech and program levels per system specifications.   ▪ Carry out the test with limiters disabled.   Using a test tone (sine wave, 1 kHz), adjust the system to the maximum achievable volume without distortion, and measure the audio level.   Perform the tests on each audio input to the system and document the results.

Metrics
System designers should calculate critical distance. When microphones are used in the system, potential acoustic gain (PAG) and needed acoustic gain (NAG) calculations are needed to determine system headroom. This is called feedback stability margin (FSM). For speech reinforcement, an FSM of 6 dB is common. For program audio, the FSM is typically 12 dB. If the design allows for enough gain and it meets the customer requirements by equaling or exceeding NAG, the audio system will perform properly. Here's an example of some considerations for a conferencing space: ▪ The measured ambient noise in the space is 45 dB SPL.   ▪ The required speech level is 62 to 68 dB SPL or 15 dB above the measured ambient noise.   ▪ The required program audio level is 70 to 75 dB SPL or 20 dB above the measured ambient noise.   ▪ Minimum target headroom would be 10 dB above normal operating level (speech or program)

Outputs
☐ Pass ☐ Fail   Measurement results:

Notes
In the system documentation, include a document that verifies the testing procedures and readings observed.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AP-131
Verification Item	Audio System Signal-to-Noise Ratio	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify audio system electrical signal-to-noise ratio meets the minimum levels defined in the project documentation. This verification item should require a metric to be verified.

Inputs
At the system input, a 1 kHz +4 dBu (IEC 60268-17) or 1 kHz 0 dBu signal

Tests, Procedures, and Equipment
Using an audio test generator and RMS multimeter:
1. Insert a measurement signal into the system
2. Measure the signal at the specified point
3. Remove the measurement signal
4. Measure noise at the specified point

Metrics	
Example: S/N = 90 dB re +4 dBu, 22 kHz BW, unity gain	**Applications**

Type	SNR
Plain old telephone service (POTS)	40 dB
AM Radio/LP records	50 dB
FM radio, cassette player	70 dB
CD player	90 dB
Human ear range (instantaneous)	85 dB
Hi-Fi studio recording equipment	120 dB
Human ear range (total)	120 dB

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes
Metrics should include the measurement values, reference level, bandwidth, filters, and gain settings of the system under test.

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Sample Video System Performance Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	VP-100
Verification Item	EDID Management Plan	Date of Verification	
Verifier		Version	
Functional Category	Video System Performance		
Verification Phases	☐ Pre-Integration ☐ Systems Integration		

Description
Verify that the EDID (Extended Display Identification Data) management plan has been implemented per the project documentation.

Inputs
All wiring is installed and terminated per system specifications.

Tests, Procedures, and Equipment
A list of systems resolutions from the project documentation shall be verified by connecting a computer or test generator that can read EDID to each system input and routing that input to each display. List the source-to-display combination that reveals a resolution contained in the system documentation but not supported by that combination.
It is recommended that a copy of software that reads and displays the EDID information is used to see the actual data being sent to a source. This is possible for any HDMI, DVI, Displayport, or VGA connection with software like EDID Manager from Extron Electronics or Monitor Asset Manager from EnTech. Some video test generators can also read and display the display device's EDID information.
The test computer or test generator shall be connected to each system input. The input shall be switched to the display and the EDID data shall be loaded with the EDID manager software. A quick visual inspection can help to determine if there are EDID issues before looking at the software.

Outputs
Use a spreadsheet to create a grid showing inputs in rows and displays in columns. Title such a grid according to the resolution found in the system documentation. A separate grid should be used for each resolution listed in the project documentation. An example is shown in the following table.

1920×1080	Description	Projector 1	Projector 2	Confidence Monitor 1	Confidence Monitor 2	Podium Monitor	Lobby Digital Signage Monitor
Description	Input/Output	1	2	3	4	5	6
Laptop 1	1	PASS	PASS	PASS	PASS	FAIL	FAIL
Laptop 2	2	PASS	PASS	PASS	PASS	FAIL	FAIL
Blu-ray Player	3	PASS	PASS	PASS	PASS	PASS	FAIL
Lectern PC	4	PASS	PASS	PASS	PASS	PASS	FAIL
Digital Signage	5	PASS	PASS	PASS	PASS	PASS	PASS

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	VP-101
Verification Item	HDCP Management Plan	**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	☐ Pre-Integration ☐ Systems Integration		

Description
Verify that the HDCP (High-bandwidth Digital Content Protection) management plan has been implemented as defined in the project documentation.

Inputs
System is fully installed and functional.

Tests, Procedures, and Equipment
Using a known encrypted video source (a Blu-ray disc of a major motion picture), play content into the video system. Route the content to all display devices and output destinations. Verify that the content is visible on all HDCP compliant displays. Verify that the content is not visible on all non-HDCP-compliant devices (e.g., VC codecs, recording devices).

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	VP-102
Verification Item	Projected Image Physical Alignment	**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that the combined installation of projector and screen provides a displayed image that is correctly aligned to the active projection screen surface without misalignment unless an alternative condition is specified in the project documentation.

Inputs
Projector and projection surface must be installed and commissioned.   Any upstream image processing used for alignment adjustment must be commissioned.   Any defined special requirements for the project (e.g., defined over-scan) must be available at the time of the verification.

Tests, Procedures, and Equipment
The simplest form of test for a rectangular screen entails projecting either a flat white field or a grid test pattern onto the intended screen surface. The alignment of each edge of the image should be verified against the edge of the projection surface. Any specified overscan should be measured and recorded; otherwise, each image edge should be checked to ensure it is aligned and square to the edge of the projection area.   If using a non-rectangular image area, create a custom test pattern to match the template that will be used for content creation. All edges of such a shape should be checked for physical alignment between the image edge and the projection surface edge.   If using projection mapping, edge blending, or similar techniques, this item would verify basic projector aim alignment in accordance with the project requirements. The final projection image alignment would be covered under VP-104 Image Geometry.

Metrics
N/A

Outputs
☐ Pass ☐ Fail   A photograph attached to the verification report showing the image alignment provides a helpful record.

Notes

InfoComm 10-2013 Verification Verification Item Form

Project Name		Verification Item #	VP-103
Verification Item	Video System Pixel Failure Tolerance	**Date of Verification**	
Verifier	Video System Performance	**Version**	
Functional Category			
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that all displayed images do not have pixel failures (bright or dead pixels) that exceed the requirements of the project documentation or the manufacturer's specifications. This verification item shall require a metric to be verified.			
Inputs			
The designer should specify the maximum allowable number of pixel defects in the project documentation. The person verifying the system performance should compare the minimum allowable pixel defects against the manufacturer's specifications.			
Tests, Procedures, and Equipment			
Using a video test generator and a full white test signal, perform a visual inspection of the displayed image to verify that there are no full dark pixels or discolored pixels due to sub-pixel failure.			
Metrics			
The designer should specify the maximum pixel defects allowed. The decision may be driven by how critical the use is, such as when very detailed viewing is required by certain medical applications.			
When the design criteria for pixel failure tolerances is not stated or known, the person performing the testing should refer to the manufacturer's specifications to ensure the flat panel is performing according to the specifications to which it was built.			
Outputs			
☐ Pass ☐ Fail Validation in accordance with specified acceptable limits			
Notes			
This item requires documentation of any defective pixels or sub-pixels.			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	VP-104
Verification Item	Image Geometry	Date of Verification	
Verifier		Version	
Functional Category	Video System Performance		
Verification Phases	☐ Systems Integration		

Description
Verify that all displayed images are correctly focused, have the correct image geometry and are free from distortion (e.g., stretching, keystone, barrel/pincushion). Any requirements for projection mapping or image shaping to unusual surfaces should be validated in accordance with the requirements of the project documentation.

Inputs
Completion of installation of all image-producing equipment
Completion of Verification Item VP-102 Projected Display Physical Alignment for projected systems
Mapping, edge blending or unusual shape image requirements to be determined from project documentation
Completion of any projection mapping/edge blending setup (required)

Tests, Procedures, and Equipment
The simplest form of test for a flat rectangular display entails displaying a grid test pattern onto the intended display surface. The image geometry should be checked to ensure that the aspect ratio of the rectangles (or squares) is maintained and that the image remains linear and regular, without curves or other distortions.
A test pattern with circles should also be displayed to ensure the circles retain their correct shape and are not squashed or stretched. Most standard test pattern generators can provide these patterns.
The system should be tested initially at the native resolution of the display, and subsequent tests should be made at all intended operating resolutions of the system.
If projection mapping, edge blending, or similar techniques are used, this item would verify the overall geometry of the final displayed images, once all image processing has been configured. Similar grid test patterns should be used, passing through the processing systems to give the final results on the display surface. The image should be viewed from multiple locations within the defined viewing area to ensure the best experience.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
A photograph attached to the verification report showing the image geometry provides a helpful record.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	VP-105
Verification Item	Displayed Image Performance	**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		

Description
Verify that the components of the displayed image system(s) (projection or direct-view) perform(s) as required with relation to image size, viewing angles, sight lines, viewer locations and/or any other requirements as defined in the project documentation.

Inputs
The display system must be fully installed. All lighting system must also be installed and have been tested and calibrated as necessary.

Tests, Procedures, and Equipment

Verify each of the following as part of the evaluation for this item:
- The image size matches the size specified in the project documentation.
- All displays are located such that all viewing angles are as specified in the project documentation.
- There are no obstructions or other conflicts with sight lines from each viewer position.
- The viewer locations meet the system requirements as defined in the project documentation.

Using a signal source, input various source materials into the display system.

Evaluate the performance based on system requirements as defined in the project documentation. In the absence of project documentation, best practices for viewing angles and sight lines are defined in the BICSI/InfoComm Audiovisual Design Reference Manual (AVDRM).

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	VP-106
Verification Item	Colorimetry	Date of Verification	
Verifier		Version	
Functional Category	Video System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify calibration of all video displays to ensure they display colors uniformly to a common reference standard as defined in the project documentation.

Inputs
Projector or display has warmed up a minimum of 30 minutes.

Tests, Procedures, and Equipment
Using a colorimeter verify the color, gamut, chromaticity, gamma, display brightness and white point, according to the project documentation. The test procedure shall follow the specific procedure and guideline as per the test equipment instructions. Referred to the following sources for additional information:

- European Broadcasting Union (EBU) Tech. 3213-E: 1975, EBU Standard for Chromaticity Tolerances for Studio Monitors
- The Society of Motion Picture and Television Engineers (SMPTE) RP 145, *SMPTE C Color Monitor Colorimetry*
- International Telecommunication Union Radiocommunication Sector (ITU-R) BT.709-5 (04/02), *Parameter values for the HDTV standards for production and international programme exchange*
- Federal Communications Commission (FCC), NTSC (1953) Color Space
- International Organization for Standardization (ISO) 10526:1999/Commission Internationale de L'Eclairage (International Commission on Illumination [CIE]) S005/E-1998, *CIE Standard Illuminants for Colorimetry* (CIE standard illuminant D65)
- CIE 15:2004, *Technical Report: Colorimetry*

Metrics
N/A

Outputs
☐ Pass ☐ Fail
Record the precalibrated state of all tested items and document the settings achieved.

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name	Multiple Resolution Performance of Video Displays	Verification Item #	VP-107
Verification Item		**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the system(s) accurately displays all resolutions required by project documentation on all displays within the system (i.e., no pixel shift, no geometric distortion, no artifacts from scaling, letterboxing, pillarboxing, or windowboxing).

Inputs
A list of input devices and their preferred (or capable) resolutions should be contained in the project documentation. If this list is not in the documentation the contractor should investigate to determine the types of input resolutions that will be expected. The system should be functionally ready to process video signals from input devices to the displays.

Tests, Procedures, and Equipment
While it is possible and preferred to use the actual input devices to test a system, at times a signal test generator may speed up the testing process. Signal test generators also include test patterns that provide more discerning images for evaluation. Testing should include a review of all input possibilities to all output displays.
Sample test products include Extron RGB 300 or 400 VTG.

Metrics
N/A

Outputs
☐ Pass ☐ Fail
Notes should indicate which resolutions failed and on which displays.

Notes

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	VP-108
Verification Item	Projected Display Brightness Uniformity	**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the combined installation of projector and screen provides a display to the viewer that meets the requirements of the project documentation. This verification item shall require a metric to be verified.

Inputs
Projected image of a full white field

Tests, Procedures, and Equipment
After the projector has warmed up for at least 30 minutes, show a fully white image on the screen. Use a photometer to measure the luminance level of the screen in the center of nine locations on the screen. The nine locations are created from dividing the image area into a 3×3 grid of equally-sized areas. The measurement should be taken on the center axis of the screen and at a distance of at least three times the width of the screen.

To calculate the uniformity percentage:
Uniformity Percentage = $((((L1 + L2 + L3 + L4 + L6 + L7 + L8 + L9) / 8) / L5) * 100)$
Where L is luminance level for each location.
1. Add the recorded luminance value for all areas except the center area.
2. Divide the total by 8.
3. Divide the calculated average by the luminance value of the center area.
4. Multiply by 100 to achieve the uniformity percentage.
The test device shall be a photometer (e.g., a luminance meter or spot photometer with up-to-date calibration) with spectral luminance response of the standard observer with photopic vision as defined in CIE S002. The acceptance angle of the meter shall be 2 degrees or less.

Metrics
>90% uniformity is good
85–90% is acceptable
80–85% is the low threshold of acceptability
<80% is not acceptable.

Outputs
☐ > 90% uniformity is good
☐ 85–90% is acceptable
☐ 80–85% is the low threshold of acceptability
☐ < 80% is not acceptable.

Notes
Provide a worksheet document showing the recorded values for each of the nine areas. The worksheet shall also show the calculations to achieve the final uniformity percentage.

AUDIOVISUAL SYSTEMS PERFORMANCE VERIFICATION GUIDE

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	VP-109
Verification Item	Projected Image Contrast Ratio	**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the system conforms to the appropriate viewing category as defined in the project documentation. The testing methodology in ANSI/INFOCOMM 3M-2011 shall be used. The projected image contrast ratio shall be measured for all projected images within the system.

Inputs
Projector is calibrated for white and black levels. Projector has warmed up a minimum of 30 minutes.

Tests, Procedures, and Equipment
Procedures 1. Measure the luminance of each white field and each black field. 2. Average all white field measurements. Average all black field measurements. 3. Divide the white average by the black average to calculate the contrast ratio. 4. Perform the measurement in five different seating positions: nearest far left, nearest far right, farthest far left, farthest far right and average center location on screen center axis. **Equipment** 4× 4 grid of alternating white and black fields Luminance meter with maximum 2-degree acceptance angle

Metrics				
	Passive	**Basic**	**Analytical**	**Motion Video**
Conforms: All locations	>7:1	>15:1	>50:1	>80:1
Partially Conforms: In four locations	>6.3:1	>13.5:1	>45:1	>72:1
Failed to Conform: Below in any location	<7:1	<15:1	<50:1	<80:1

Outputs
System Type (check one): ☐ Passive ☐ Basic ☐ Analytical ☐ Motion Video **Measured Contrast Ratio:** Loc #1 ____:1 Loc #2____:1 Loc #3____:1 Loc #4____:1 Loc #5____:1 ☐ Conforms ☐ Partially Conforms ☐ Fails to Conforms

Notes
The Standard requires a plan layout of the room and a worksheet containing measurements. Refer to the Standard for more information.

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	VP-110
Verification Item	Video Routes	**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that all video routes are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and routing required by the project documentation.

Inputs
All video wiring is installed, labeled, and terminated.

Tests, Procedures, and Equipment
Provide a test signal or source at each input location and verify that the signal is present at the output of the associated wire. A spreadsheet noting each cable with cable number should be used to track that each cable is tested. A video test generator or laptop may be used to verify that the image is present at every output display. This test shall be repeated for every input to every output.

Metrics
N/A

Outputs
☐ Pass ☐ Fail Provide a spreadsheet identifying each cable identified and confirming whether they have passed the test.

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	VP-111
Verification Item	Video Camera Image and Operation	**Date of Verification**	
Verifier		**Version**	
Functional Category	Video System Performance		
Verification Phases	❑ Post-Integration		
Description			

Verify that cameras, lenses, and pan/tilt systems operate as defined in the project documentation. Inspect the camera image through the full lens operation.

Inputs

Reference the project documentation for mounting and operational requirements. The intent of this test is to ensure that the camera, lens, and pan tilt assembly operate in a consistent and uniform fashion within the intended image frame area(s).
This test is especially important when a separate camera and pan tilt head assembly is integrated and cabling is routed externally as cables can be easily pinched or caught within the assembly if not harnessed correctly.

Tests, Procedures, and Equipment

Visually inspect the installed equipment ensuring that the camera assembly is mounted and all cabling is harnessed to avoid mechanical obstruction within the limits of the device movement area.
Ensure that pan and tilt limits have been set and that the assembly cannot accidentally come in contact with any known movement obstructions (e.g., walls or ceiling elements). Move the camera through the entire pan-and-tilt range to ensure smooth operation. Ensure that zoom and focus functions operate throughout the full range of the lens and that the back focus (if applicable) is properly adjusted.

Metrics

N/A

Outputs

❑ Pass ❑ Fail
Measurement Result:

Notes

Sample Audio/Video System Performance Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AVP-100
Verification Item	Emergency Notification	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio/Video System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that emergency communications systems properly receive inputs and information from other systems (including but not limited to life safety systems, security systems, and weather notifications), deliver appropriate notifications to target audiences, comply with regulatory requirements, and adhere to requirements defined in the project documentation.			
Inputs			
Audio and video systems are fully operational. Any dependent or connected life safety system also shall be functional.			
Tests, Procedures, and Equipment			
Reference any specific tests called out in the project documentation. Also reference any specific codes or laws pertaining to the AV system's function in relation to or as part of a life safety system. List each life safety system that is interacting with the AV system. List each situational process, the expected result, and note if it passed. This may be, "Fire Alarm (Trigger), Audio system enters a muted state (Action), Passed."			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			
Provide a spreadsheet showing each location, the situational process, and the expected result.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AVP-101
Verification Item	Genlocking (Video Synchronization)	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio/Video System Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that the video synchronization of the system is performing as defined in the project documentation.

Inputs

Analog Video
1. Ensure the equipment can be timed. Some equipment may only be timed using certain outputs, and not on all available outputs.
2. Ensure the equipment has some provision for the adjustment of timing, whether it is a single control for adjusting both H-timing and SC-phase or separate controls for adjusting each.
3. For any devices that are not capable of accepting external sync, a time base correctors (TBC) would be used to provide both timing and color correction as required for items (e.g., consumer VTRs or cameras).
4. Refer to the service/application manual for the video switch/special effects generator for instructions regarding specific sync input requirements and processor settings for calibration.

Digital Video (SDI, HD-SDI, 3G-HD-SDI)
1. Ensure the equipment can be timed. Some equipment may only be timed using certain outputs, and not on all available outputs.
2. For devices that do not have sync reference inputs that need to be connected and timed, a digital frame synchronizer would be used to provide both timing and color correction as required.
3. Many special effects generators contain digital frame synchronizers on all or some of their inputs. If the SEG contains a digital frame synchronizer internal to the device, adjustments are minimal.
4. Refer to the service/application manual for the video switch/special effects generator for instructions regarding specific sync input requirements and calibration procedures.
5. For SDI video with embedded audio (ANSI/SMPTE standard 272M), it is important to ensure that audio is in time with the video stream. A waveform rasterizer provides measurements for both video and audio data streams.

Tests, Procedures and Equipment

Analog Video
Refer to the following documentation for calibration and testing:
▪ "Setting Up A Genlocked Studio" by Tektronix
▪ NTSC, PAL, and SECAM standards

Digital Video
Refer to the following documentation for calibration and testing:
▪ "Digital Video Measurements" by Tektronix
▪ SMPTE 318, SMPTE 259M, SMPTE 344M, SMPTE 292M, SMPTE 372M, and SMPTE 424M standards
Also see "Timing and Synchronization in a Multi-Standard, Multi-Format Facility" by Tektronix.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AVP-102
Verification Item	Audio and Video Recording	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio/Video System Performance		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post Integration		

Description
Verify that audio and video signals are being routed to the recording device(s) and that the recording device(s) is operating correctly, as defined in the project documentation.

Inputs
All audio wiring is installed, labeled and terminated. Source devices and intermediate routing/switching/mixing devices can route sources to recording devices.

Tests, Procedures, and Equipment

For audio, ensure that:
- It's free from distortion.
- Assuming the audio system gain structure is correct, a unity gain level from the mixing or source device produces unity gain at the recording device.
- The channel separation is correct (left and right channels are correct).

For video, ensure that:
- The aspect ratio is correct.
- The frame rate, compression, or other codec-related factors are optimized as per the specification.
- Audio and video are properly synchronized.

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale

Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

Where issues are detected, it is recommended that a second level of testing is employed using specialist protocol analyzers to look at bit error rates, packet loss, and processing and timing issues. Networks should also be reviewed for their impact as part of the related verification item IT-100 Content Delivery Network.

Metrics
N/A

Outputs
Provide a sample audio or video recording with the project documentation.

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AVP-103
Verification Item	Audio/Video Sync	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio/Video System Performance		
Verification Phases	☐ Post-Integration		
Description			
Verify that audio/video synchronization is maintained to ensure the proper time alignment of signals during playback at the point of user experience or transmission as defined in the project documentation. This verification item should require a metric to be verified.			
Inputs			
An AV system is commissioned, and all recording devices, presentation equipment and link equipment/circuits are operational.			
Tests, Procedures, and Equipment			
A blip-and-flash test is a common method for measuring the synchronization of audio and video. A test signal consisting of one full frame of white video, accompanied by the same time length of audio tone, is required. An alternative signal may be an image changing from full-frame white to full-frame black at regular intervals, with each change accompanied by a brief click or tone burst. This can be generated by a laptop running a slideshow.			
The signal at the point of reception can then be analyzed using a dual-channel digital storage oscilloscope to record the timings at which the audio and video signals are received.			
If a metric is not being measured, then a subjective reception test using the same test signal may be used, in addition to a replay of video material that depicts a person speaking (e.g., a newsreader). The subjective effect of any delay can then be reviewed for a pass/fail assessment.			
Tests should be undertaken at the inputs of recording devices, the inputs to transmission devices (e.g., VC codecs, broadcast circuits), and locally within the presentation space at both near-screen and farthest-viewer positions.			
Metrics			
In the absence of defined requirements in the project documentation, the recommended maximum error whereby the audio should lead the video is +40 ms and whereby the audio should lag behind the video is –60 ms throughout an entire signal chain. These equal to two or three frames on 50 Hz-video systems.			
For television applications, the recommended maximum synchronization error is +15/–45 ms. A positive number indicates that the audio is in advance of the video.			
Outputs			
☐ Pass ☐ Fail			
Notes			
Record results for each location.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	AVP-104
Verification Item	Radio Frequency Television Distribution	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio/Video System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the radio frequency and satellite intermediate frequency distribution systems provide all services to all endpoints as defined in the project documentation. This verification item shall require a metric to be verified.

Inputs
An RF distribution system is fully installed and commissioned to all outlets.

Tests, Procedures, and Equipment
Free-to-air analog, free-to-air digital, pay television satellite dish or cable connection, and coaxial and/or optical fiber distribution systems should be installed prior to testing.
Testing should be carried out at each outlet individually, with the system operating with all outlets connected (i.e., at full operational load).
A simple signal level meter that is calibrated in dBµV is sufficient for basic level tests. A more advanced analyzer such as Sencore SLM 1475 or Schomandl SM120 may be necessary for carrier-to-noise (C/N) ratio and bit error rate (BER) measurements.
Test against the following parameters:
▪ Signal levels within the stated range—Excessively high signal levels may overload receiver input stages.
▪ Signal/noise (S/N) ratio (C/N ratio)—Higher signal levels are better and they must meet minimum required levels.
▪ Bit-error rate (digital signals)—Lower signal levels are better and they must not exceed maximum required level.

Metrics
Metrics will be sourced from the national broadcast, cable, and/or satellite standard for the system to be installed. This varies from country to country and, in some cases, region to region.

Outputs
☐ Pass ☐ Fail

Notes
The results of the measurements at each outlet should be recorded and verified against the determined metrics, and a pass/fail result should be recorded for each.

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	AVP-105
Verification Item	Source Testing	**Date of Verification**	
Verifier		**Version**	
Functional Category	Audio/Video System Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the signal produced by a source typical of what will be used in normal operation of the system is routed through the system to applicable endpoints and produces the performance as defined in the project documentation. A test generator shall not be used for this verification item.

Inputs
All equipment installed and functional.

Tests, Procedures, and Equipment
Play media in source devices of multiple different formats and resolutions. Verify that the playback of the devices performs as noted in the project documentation (e.g., resolution, scaling, aspect).   For fixed PCs provided by the owner, verify the resolution settings, aspect ratios, and scaling.   For guest laptop inputs, request from the owner a representative laptop (and possibly tablet device) to test the system inputs. Test the laptop at the native resolution in a cloned desktop mode, and in an extended desktop mode.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

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Sample Cable Management, Termination, and Labeling Reference Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-100
Verification Item	Cable Bend Radius	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Pre-Integration ☐ Systems Integration		
Description			
Verify that cables are not bent beyond their minimum bend radius as specified in cable data sheet in order to maintain signal integrity as defined in the project documentation. Project documentation may state a larger radius to allow for a safety margin.			
Inputs			
Pre-Integration Phase: Inspect and verify all conduits, conduit bends, pull-boxes, and back-boxes, before walls and ceilings are installed for correct sizing for cable capacity and to maintain proper bend radius. Inspect and verify all external raceways and furniture routing for correct sizing for cable capacity and to maintain proper bend radius. **Systems Integration Phase:** All cables are installed and terminated.			
Tests, Procedures and Equipment			
Review and determine cable manufacturers' literature for bend radius requirements and applicable standard(s) for figuring conduit capacity and pull-box sizing. Perform visual inspection and measurement with ruler or tape measure.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-101
Verification Item	AV Connector Plate Input and Output Labeling	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		
Description			
Verify all AV connector plate input and output labeling as defined in the project documentation.			
Inputs			
All connection panels are terminated and fitted. System schematics and project labeling requirements are complete.			
Tests, Procedures, and Equipment			
This item should include both a physical inspection of all panel labels and verification that the label information is accurate in the context of the system function, as indicated on the drawings. The physical assessment should ensure that the labeling is the correct type and durability as required by the project documentation and that it meets good practice. Appropriate labeling could be direct panel engraving, applied engraved labels, machine printed labels, or similar. Text should be typewritten, never handwritten, and the labeling should be durable and not easily removable. Text color should provide good contrast to the background color, and the text size should not be too small or too large such that sufficient information can fit the available space. Labeling accuracy should be verified by checking the connector function in the system design. For example, if an input is labeled PC 1, then pressing PC 1 on the control panel should activate that input.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
A detailed record of the inspected panels, physical verification of the information listed on the labels, and the accuracy of the information listed by connector provides for a complete and correct verification of this item.			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-102
Verification Item	AV Connector Seating	Date of Verification	
Verifier		Version	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that all AV connectors are correctly keyed, seated, and latched to respective connection points as defined in the project documentation. Conditions where physical parameters exceed the connector's ability to maintain full seating should be resolved as defined in the project documentation.

Inputs
All AV connections are complete.

Tests, Procedures, and Equipment
Tests   Visual inspection of the connectors is required. The inspection should ensure that all connectors are fully and squarely mated, and that all locking mechanisms, clamps, latches, and lock screws are fully tightened/engaged.   **Procedures**   Visually inspect that the AV connectors are making full engagement.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Refer to InfoComm *AV Installation Handbook, Second Edition*, and InfoComm installation courses. Follow the recommended manufacturer termination techniques.   In situations where certain connector types are not maintaining a full engagement (i.e., gravity against a non-latching connector), implement an alternative installation method should be implemented.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-103
Verification Item	AV Connector Verification	Date of Verification	
Verifier		Version	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that all cable terminations are made securely and meet the recommendations of the connector and cable manufacturer, published standards, as well as the requirements defined in the project documentation.

Prerequisites Conditions
All AV connections are complete.

Tests, Procedures, and Equipment
Visual inspection of the connectors is required. Termination connectors shall be inspected for workmanship, physical integrity, and appropriate preparation of wire conductors or optical fibers. The inspection may require partial disassembly or removal of connector covers or shells. All connectors shall be clean and free of any dirt or debris. All terminated cables shall be supported and dressed in accordance with the project specifications, including the use of appropriate wire management products (e.g., heat shrink, split loom, wire ties, Velcro ties, tape). Refer to InfoComm CTS-I documentation, cable termination best practices, and connector/cable manufacturers' termination schemes. Follow project documentation if there is a possibility of using more than one connector type.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-104
Verification Item	AV Power Cable Management	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that all AV equipment power cables are managed as defined in the project documentation. Verify that cables are managed in a uniform and acceptable manner so as not to compromise safety/OEM warranty, AV signal quality, and/or future field service.

Inputs
Power cabling is installed in AV equipment racks, control desks, credenzas, joinery, and millwork.

Tests, Procedures, and Equipment
Check to make sure that there is adequate separation between power cables (110–230 V) and AV cables. Verify that power cables are routed in a manner that allows devices and power supply transformers to be serviced. When devices have permanently attached power cables, ensure that the power cables are fastened with a reusable cable tie or hook and loop.

Metrics
N/A

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-105
Verification Item	AV System Cable Labeling	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that all cables are identified by a unique ID as defined in the project documentation. Verify that this unique ID is displayed permanently at both ends of the cable, is legible, and is positioned where it can be seen without undue disturbance.

Inputs
All cables are installed, terminated and labeled. System schematics, cable schedules, project labeling requirements are complete.

Tests, Procedures, and Equipment
Identify the project's specified/required labeling requirements. These may be contained in the project documentation, company workmanship guides, or other best practice documentation. The project documentation will always take precedence.   The cable labeling at each end of each cable should be visually checked to ensure that it meets the requirements determined for the project. The labeling should be verified against requirements for: ▪ Legibility—Typewritten/machine printed labels (i.e., not handwritten, good contrast). Color coding may also be used if required.   ▪ Durability—The label should stand the test of time without fading or suffering effects of wear (especially on flexible connecting cords).   ▪ Accessibility/visibility—The labels should be easily readable without needing to disturb the cable loom or move other equipment.   ▪ Accuracy—Labeling should be checked against the system drawings/cable schedules to ensure it matches and each label/identifier is unique to that cable. It may be acceptable to use the same identifier in multiple rooms/systems of the same type on a single project, but an identifier should never be duplicated within a single system.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Labeling that does not meet the requirements of the project should be highlighted for rectification. An inspection record against the system schematics or cable schedule to show the checking of each end of each cable would provide for a more complete verification record.

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InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	CABL-106
Verification Item	Cable Separation	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that both site and rack cables have appropriate separation according to signal type and level as defined in the project documentation.

Inputs
All wiring is installed and terminated per system specifications.

Tests, Procedures, and Equipment
Visually verify the following as pass/fail: ▪ Cables are bundled based on different signal types.   ▪ Cables with the greatest difference in signal level should have the farthest separation.   ▪ At the rear of a rack, the speaker level, RF, control, power, ground, and networking cables should be bundled individually on the left. Also at the rear of the rack, the microphone level, line level, video, RGBHV, digital control code or time code, and digital video cables should be bundled on the right.   ▪ Separation of different signal types shall be a minimum of 100 mm (4 in) within a rack.   Separation of different signal types shall be in separate conduit or raceway, when not in the rack, or in partitioned raceway.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
To enable auditing to provide evidence of correct procedures, taking photos prior to closing walls and ceilings is recommended.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-107
Verification Item	Cable Supports	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		
Description			
Verify that all cables are supported throughout their lengths as defined in the project documentation.			
Inputs			
Cable supports are installed.			
Tests, Procedures, and Equipment			
Check that the cable supports are placed in a manner than prevents cables from hanging or sagging to ensure they don't put stress on the cable itself or terminations.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-108
Verification Item	Cable Ties	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		
Description			
Verify that, where appropriate, cable ties are used to secure the cables, are correctly tensioned, and that the correct type of cable tie is used in the project as defined in the project documentation.			
Inputs			
Cable ties are installed.			
Tests, Procedures, and Equipment			
Visual inspection is all that is required to verify this item. Cable ties should be placed or staggered in a neat and orderly fashion. Ensure that excess pressure is not being placed onto the cable, causing indentation or deformation. When cutting cable tie excess, ensure that no jaggies or sharp corners are left behind. When using cable bundles, size should not exceed the manufacturer's or code specifications. It is appropriate to have the cable tie length match the correctly sized cable bundle.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-109
Verification Item	Cables Bundled By Type	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that cables are only bundled together when their construction, signal type, and signal level are compatible and will not cause measureable crosstalk or interference between cables.

Inputs
All wiring is installed and terminated per system specifications.

Tests, Procedures, and Equipment
Visually verify the following as pass/fail:
- Cables are bundled based on different signal types.
- Cables with the greatest difference in signal level should have the farthest separation.
- At the rear of a rack, the speaker level, RF, control, power, ground, and networking cables should be bundled individually on the left. Also at the rear of the rack, the microphone level, line level, video, RGBHV, digital control code or time code, and digital video cables should be bundled on the right.
- Separation of different signal types shall be a minimum of 100 mm (4 in) within a rack.
- Separation of different signal types shall be in a separate conduit or raceway/skirting duct, when not in the rack, or in partitioned raceway/skirting duct.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	CABL-110
Verification Item	Cables Dressed	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that cables are dressed to ensure that all rack and site cables are installed to provide serviceability, safety, and aesthetics as defined in the project documentation.

Inputs
All wiring is installed and terminated per system specifications

Tests, Procedures, and Equipment
Visually verify the following as pass/fail: ▪ Cables are supported by cable management rings, stress relief loops, lacing bars, or other horizontal and vertical support structures so that the termination point does not bear the weight of the cabling. ▪ Cables are neatly organized into groups (see verification item CABL-106 Cable Separation). ▪ Cables are trimmed to length for bulk wiring, leaving only a service loop that is neatly secured in the rack. ▪ Verify there are no splices in the cabling. ▪ Premade cables are the appropriate length and secured so that non-locking connectors remain in place. ▪ Appropriate cable ties are used. Velcro straps are preferred. Verify that any cable/zip ties are secure but not tight to the point where the cable jacket is deformed. Cable/zip ties should not be used on optical fiber or network cabling. ▪ Cabling entering or exiting the rack has the appropriate jacket, sleeve, or bundling and enters or exits the rack through the appropriate opening in the rack. In the case of pullout or swinging racks, the cabling has the appropriate extra length required for the rack to move in the full range without undue tension or strain on the bundle. Within that range of movement, the bundle maintains the appropriate bend radius. Abrasion points are noted and addressed. Knockouts in racks have grommets or other protection for the cabling so that any rack movement will not cause cable wear over time.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-111
Verification Item	AV Patch Panel Configuration	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	❑ Systems Integration		

Description
Verify that all patch panels have been correctly wired and configured as defined in the project documentation.

Inputs
All patch panels are terminated and fitted. System schematics are complete.

Tests, Procedures, and Equipment
This item should include a physical inspection of all patch panels and verification that the wiring and configuration is accurate in the context of the system function, as indicated on the drawings. This should include testing for: ▪ Polarity (phase) for audio signals ▪ Normalization (correct pass-through of normalized signals, which are broken according to the specified half-, full- or double-normalized) for audio signals ▪ Provision of U-links or jumper cables for normalizing on video or other patch panels

Metrics
N/A

Outputs
❑ Pass ❑ Fail

Notes
A detailed record of the panel testing (e.g., by marking up a copy of the relevant system schematic) would be beneficial.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-112
Verification Item	AV Patch Panel Labeling	Date of Verification	
Verifier		Version	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		

Description
Verify that all patch panels have been labeled as defined in the project documentation. Verify that all labeling is machine-printed, consistent, durable, accurate, and legible.

Inputs
All patch panels are terminated and fitted. System schematics and project labeling requirements are complete.

Tests, Procedures, and Equipment
This item should include both a physical inspection of all panel labels and verification that the label information is accurate in the context of the system function, as indicated on the drawings.
The physical assessment should ensure that the labeling is the correct type and durability as required by the project documents and meets good practice. Appropriate labeling could be direct panel engraving, applied engraved labels, machine printed labels strips, or similar.
Text should be typewritten, not handwritten, and the labeling should be durable and not easily removable. Text color should provide good contrast to the background color, and the text size should not be too small to read (no more than two lines of text) or too large such that sufficient information cannot be provided in the space available. Label pitch must match the pitch of the patch panel connectors and the label should be held in place so that it cannot slide off easily.
Labeling accuracy should be verified by checking the connector function in the system design (e.g., a patch connection labeled mixer input 1 should connect to the corresponding mixer input).

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
A detailed record that verifies the accuracy of the patch panel labeling should be developed through system testing (e.g., by marking up a copy of the relevant system schematic).

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-113
Verification Item	Termination Stress	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Systems Integration		
Description			
Verify that all cable terminations have been completed and adequately supported so as to minimize stress on the termination point and/or connector.			
Inputs			
Cabling is installed.			
Tests, Procedures, and Equipment			
Ensure that there is a sufficient amount of cable strain relief included to prevent deterioration of proper terminations.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-114
Verification Item	AV Connector Plate Consistent Labeling	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Post-Integration		

Description
Verify that AV connector plates have consistent labeling throughout the project as defined in the project documentation.

Inputs
All connection panels and patch panels terminated and fitted. System schematics, panel layout drawings, and project labeling requirements are complete.

Tests, Procedures, and Equipment
The label text on all panels and connectors in the system should be inspected and checked against all other items that are relevant to that label. It should be consistent with the system schematic drawings, the panel layout drawings, patch panels, functional descriptions, and control functions (e.g., if you press the button labeled camera 1, then the camera connected to the panel labeled camera 1 should activate).
Labels on link cabling should be consistent, although this may not be identical if a designated direction of signal travel is required (e.g., a link cable between room 1 and room 2 may say "To room 2" at one end and "From room 1" at the other).

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Inconsistencies should be highlighted for rectification, along with a recommendation as to which element should change to correct the inconsistency (e.g., the drawing, the panel label, patch panel label).

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-115
Verification Item	AV System Cabling Verification	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Termination, and Labeling		
Verification Phases	☐ Post-Integration		
Description			
Verify that all cabling is of the correct type and routed correctly from point to point as defined in the project documentation.			
Inputs			
All cables are installed and finally dressed. Project cabling specifications and cable routing/containment drawings are complete.			
Tests, Procedures and Equipment			
Perform visual inspection of cable types and routings. It is considered good practice to complete additional performance testing based on type, especially when high demands are placed on a particular cable (e.g., HDBaseT). Performance testing is also recommended for optical fiber links.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CABL-116
Verification Item	Cable Length Required for Serviceability	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management, Installation, and Labeling		
Verification Phases	☐ Post-Integration		
Description			
Verify that sufficient cabling is available so the device can be placed in a serviceable location as defined in the project documentation.			
Inputs			
All cabling is installed.			
Tests, Procedures, and Equipment			
Visually inspect the cabling to ensure that moving and removing the equipment allows for easy access and does not disturb other rack components. If disconnection is required, ensure that the equipment can be moved sufficiently to allow visual identification of the disconnection point.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

Sample Control System Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CON-100
Verification Item	Control System Communications	**Date of Verification**	
Verifier		**Version**	
Functional Category	Control Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that all control communications are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and functionality as defined in the project documentation.			
Inputs			
Control systems and supporting network and equipment are installed and ready for testing.			
Tests, Procedures, and Equipment			
Identify all control paths and functions as defined in the project documentation. Monitor communications between the touchpanel and the processor, between all control devices, and from each networked device. While monitoring, activate control functions associated with the monitored link and ensure that the data transfer is correct and the desired function(s) occur. Equipment should include a laptop or desktop computer with appropriate software.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail List all control paths and functions as tested.			
Notes			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #		CON-101
Verification Item	Control System Interfaces	**Date of Verification**		
Verifier		**Version**		
Functional Category	Control Performance			
Verification Phases	☐ Systems Integration ☐ Post-Integration			

Description
Verify that AV control system interfaces to and from control systems provided by others conform to requirements as defined in the project documentation.

Inputs
The control system interface is installed and ready for testing.

Tests, Procedures, and Equipment
Test each interface, function, and operation for all external systems controlled by the AV control system. For example, when testing the operation of the lighting interface, check for preset changes that are corresponding to a change in the lighting level based on the selected touchpanel button function.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
List interfaces and functions tested.

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	CON-102
Verification Item	Mobile Device Integration	**Date of Verification**	
Verifier		**Version**	
Functional Category	Control Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that mobile devices that are to be supported are integrated and operating as defined in the project documentation.			
Inputs			
Mobile devices are integrated.			
Tests, Procedures, and Equipment			
Check the project documentation for required functionality. Ensure that the mobile device is connected to the wireless network and that selecting all commands results in the desired action or effect. For a control example, pressing the volume button on the mobile device should ramp up the program volume in the space. For a BYOD scenario example, pressing the Share button would share video content to the selected screen or screen processor. Review the system operation for any control dropout, where the control surface loses synchronization with the system. Where a control dropout occurs, further investigation will be required into the configuration of the device and wireless and wired network under items IT-103 Network QoS (Quality of Service), IT-114 Network Performance Under Full Functional Load, and WL-101 Wireless Control Systems Operation.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			
A simple pass/fail reporting is all that is required by the Standard.			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CON-103
Verification Item	System Response to Emergency Condition(s)	Date of Verification	
Verifier		Version	
Functional Category	Control Performance		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that any required response of the installed AV systems in the event of a life safety or similar emergency operates in accordance with local regulations and as defined in the project documentation. This item specifically excludes sound system response to an emergency condition, which is covered under item AP-100 Emergency Muting.			
Inputs			
Control systems are installed.			
Tests, Procedures, and Equipment			
Refer to the project documentation to confirm the required emergency actions. Initiate fire alarm activation via coordination with the fire alarm contractor or manually trigger the event simulating how the control system sees the activation. Confirm that the required action occurs when either of the two tests above is conducted.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail Measurement Result:			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CON-104
Verification Item	Control System Automated Functions	**Date of Verification**	
Verifier		**Version**	
Functional Category	Control Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that all time-dependent or automated functions executed by the control system conform to requirements as defined in project documentation.

Inputs
Review the project documentation and identify automated functions required to be verified.

Tests, Procedures, and Equipment
The implementation of automated and time dependent functions within a control system requires due diligence and specific testing to ensure that the desired event related results are achieved via both interface and programming tasks.   Automated functions include automatic power on/off, interface with building management systems for climate control and single button push multi-function commands.   Review the project documentation and confirm that all automated room functions are supported by the control system program and interfaces.   An example test would be an automated system power off sequence. This would be accomplished by changing the end of day time to a few minutes prior to the test. What we would expect for example would be for the display and system to power down, lights raised to full, shades raised and non-essential equipment turned off.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CON-105
Verification Item	Control System User Interface Performance	**Date of Verification**	
Verifier		**Version**	
Functional Category	Control Performance		
Verification Phases	☐ Post-Integration		

Description
Verify that the control system is implemented in a manner consistent with the requirements as defined in the project documentation.

Inputs
Control systems are installed.

Tests, Procedures, and Equipment
Review the project documentation and confirm that all of the intended room functions are supported by the control system program and user interface in a manner that provides all intended AV functionality.

Metrics
N/A

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	CON-106
Verification Item	Control System Response Time	**Date of Verification**	
Verifier		**Version**	
Functional Category	Control System		
Verification Phases	☐ Post-Integration		

Description
Verify that the control system provides the user response time and maximum latency defined in the project documentation. This verification item should require a metric to be verified.

Inputs
The total latency of an AV control system is determined by several factors to include processor speed, operating system, network traffic and data exchange requirements determined by custom code written based on project requirements.

Tests, Procedures, and Equipment
Review the project documentation and confirm that the user interface is responsive to touch operation and does not contain latency that would lead the user to believe the system is not functioning or operating sluggishly.

Metrics
Refer to these guidelines from chapter 5 of *Usability Engineering* (1993):

- 0.1 second is about the limit for having the user feel that the system is reacting instantaneously, meaning that no special feedback is necessary except to display the result.
- 1.0 second is about the limit for the user's flow of thought to stay uninterrupted, even though the user will notice the delay. Normally, no special feedback is necessary during delays of more than 0.1 but less than 1.0 second, but the user does lose the feeling of operating directly on the data.
- 10 seconds is about the limit for keeping the user's attention focused on the dialogue. For longer delays, users will want to perform other tasks while waiting for the computer to finish, so they should be given feedback indicating when the computer expects to be done. Feedback during the delay is especially important if the response time is likely to be highly variable, since users will then not know what to expect.

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes

Sample Electrical Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	ELEC-100
Verification Item	AV Equipment Connected to Proper Circuit	**Date of Verification**	
Verifier		**Version**	
Functional Category	Electrical		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that all AV equipment is powered from the designated power circuit and outlet as defined in the project documentation. No additional (non-AV) equipment should be connected unless permitted in the project documentation.			
Inputs			
Electrical contractor has completed their work and supplies a knowledgeable individual with the skills and equipment necessary to demonstrate compliance to project documents and regulatory requirements. Up-to-date project documents showing all circuits and outlets are available.			
Tests, Procedures and Equipment			
The best and most accurate method of ensuring outlets are supplied by the proper circuit is to perform a walkthrough with the electrician responsible for the installation of AV electrical circuits. Once the outlets have been mapped to their corresponding circuits, power assignments can be confirmed.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	ELEC-101
Verification Item	Grounding/Earthing	**Date of Verification**	
Verifier		**Version**	
Functional Category	Electrical		
Verification Phases	☐ Pre-Integration ☐ Systems Integration		
Description			

Verify that all elements of the AV system are correctly bonded to an electrical ground/earth in accordance with the requirements of the regulatory authority and as defined in the project documentation.

Inputs

Permanent power/electrical system is operational. Safety earthing system is fully installed back to the main earth stakes/grid/mat. Technical earthing system is fully installed.

Tests, Procedures, and Equipment

First-pass testing should identify serious problems through either an audible 50/60-Hz hum or visual bars on displays. Once a problem is detected, the following actions are recommended:
1. Disconnect all connections from the equipment (including power and signal lines) and reconnect the equipment and connections one by one. Stop when the hum becomes audible/visible.
2. Review equipment manuals and schematics to determine how the grounding for each equipment type is configured (e.g., the difference between the signal ground and the safety earth [power outlet]). Equipment can be the source of a ground loop and, in some instances, audio or signal isolators can easily be applied and maintain the integrity of the safety earth.
3. Review the cabling to determine if any incorrect wiring/termination is present (e.g., using the shield of a cable for signal).
4. Review with the electrical contractor that safety earthing has been completed in accordance with the project documentation. It is best practice for all interconnected AV equipment to also be on the same electrical circuit and, therefore, the ground circuit. If the equipment is not connected in such a way, it can be temporarily connected in this manner via a power-board to determine if this is an appropriate solution.
5. Perform a technical earthing review with the electrical contractor to ensure that the safety earthing has been completed in accordance with the project documentation.

Request that an electrical contractor performs testing as part of their work, as follows:
1. Use a meter to measure the ground signal at different points in an installed system.
2. Verify that the ground level difference between system equipment is less than 1 Ω.

Metrics

No Metrics associated with this item.

Outputs

☐ Pass ☐ Fail

Notes

Note ground voltage and potential.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	ELEC-102
Verification Item	Mains Voltage Sub-distribution integrity	Date of Verification	
Verifier		Version	
Functional Category	Electrical		
Verification Phases	☐ Pre-Integration		

Description
Verify that all electrical sub-distribution systems provided by the AV contractor in equipment racks, furniture, and similar structures meet local regulatory requirements for electrical integrity.

Inputs
Identify the systems to be verified and confirm the local requirements for testing.

Tests, Procedures, and Equipment
If the distribution systems are connected to the supply via a standard mains plug, the system may be tested as an appliance using a simple portable appliance tester (e.g., manufactured by Fluke, Seaward, Kewtech, Martindale). Alternatively, skilled personnel may use test equipment for electrical circuits. To avoid damage, manufacturers' instructions must be followed and electronic equipment may need to be disconnected from the distribution system prior to testing.
Apply measurements/verification of each element as required by local codes. While this item does not require a metric, if local codes require specific measurements, they should be identified and recorded.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
A more comprehensive reporting, providing a record of the tests undertaken and any recorded values, would be beneficial.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	ELEC-103
Verification Item	Power Sources	**Date of Verification**	
Verifier		**Version**	
Functional Category	Electrical		
Verification Phases	☐ Pre-Integration		

Description
Verify that the sources of mains voltage AC power to be used for the supply of AV equipment are correct as defined in the project documentation and have been tested to the outlet in accordance with local electrical standards.

Inputs
Identify the correct power outlets to be used for connecting the AV equipment (see ELEC-100 AV Equipment Connected to Proper Circuit), and also confirm the person responsible for carrying out the outlet testing.

Tests, Procedures, and Equipment
The AV contractor should confirm with the person responsible for the testing that it has been carried out and that the test results match the supply requirements in the project documentation. Ideally, this will be carried out by inspection of the electrical test paperwork, but if this is not available, then written confirmation from the person responsible for carrying out the testing will suffice.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
A more comprehensive reporting, providing a record of the tests undertaken and any recorded values, would be beneficial. Copies of the electrical test documentation may be attached.

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InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	ELEC-104
Verification Item	Power Sequencing	**Date of Verification**	
Verifier		**Version**	
Functional Category	Electrical		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that the power sequencing of devices is correct as defined in the project documentation.			
Inputs			
The system is fully installed and functional			
Tests, Procedures, and Equipment			
When all equipment is installed and functional, power on the equipment and note any issues in the sequence. Power the system down and verify that the sequence is in the proper order (usually the reverse of power-on). Verify that equipment that needs constant power remains on.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Note any issues relating to power sequence.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	ELEC-105
Verification Item	UPS Operation	**Date of Verification**	
Verifier		**Version**	
Functional Category	Electrical		
Verification Phases	☐ Systems Integration ☐ Post Integration		
Description			
Verify that the uninterruptible power supply (UPS) is performing to the specifications as defined in the project documentation.			
Inputs			
The system is fully functional allowing the testing of UPS reserve power.			
Tests, Procedures and Equipment			
Remove power/unplug the UPS unit from the power source. Devices connected to the UPS should remain powered on for the time specified in the project documentation. Any required orderly shutdowns prior to the UPS expiry should also be checked (i.e., system server or control system shutdown).			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Refer to the project documentation for this report.			

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	ELEC-106
Verification Item	DC Power Distribution	**Date of Verification**	
Verifier		**Version**	
Functional Category	Electrical		
Verification Phases	☐ Systems Integration		

Description
Verify that all DC-powered devices are receiving the proper voltage and current for normal operation.

Inputs
The system is fully installed and functional.

Tests, Procedures, and Equipment
When all equipment is installed and functional, power the equipment on. Using a clamp-type ammeter (Fluke 325 or equivalent) capable of reading DC power, take a reading of the voltage and current as close to the device as possible. This is important because voltage drops occur over long power wiring. A 12-V power supply may not deliver 12 V if the cable run is long and the wire gauge is undersized for the application.   When multiple devices are being powered from a single power supply (e.g., Crestron CNPWS-75 or Extron PS124), the power supply shall be listed on the spreadsheet. Add all current readings from all devices receiving power from the single power supply. The current shall not exceed the maximum current rating of the power supply or the current-per-port specification for the power supply.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
A spreadsheet shall be made listing all DC-powered devices, the required voltage, and required current. A column for measured voltage and measured current shall also be listed.

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	ELEC-107
Verification Item	Power Loss Recovery	**Date of Verification**	
Verifier		**Version**	
Functional Category	Electrical		
Verification Phases	☐ Post-Integration		

Description
Verify that the AV systems resume normal operation on the restoration of power following a hard electrical power outage. Power loss recovery shall include verification of the resumption state on power recovery. Resumption state shall be the control system start-up condition/start page (where applicable) and resetting all devices to a known state as defined in the project documentation.

Inputs
Each project has specific procedures for the control of electrical power to enable the simulation of a hard electrical outage, and they shall be followed. In many countries, only a qualified electrician should perform this test to comply with the relevant safety regulations.

Tests, Procedures, and Equipment
If each equipment rack has its own uninterruptible power supply (UPS), two levels of testing are recommended to be conducted as follows: 1. Switch off the mains and let the UPS run to full shutdown. 2. Simulate full interrupted power by running UPS in bypass or disconnecting and switching off the mains distribution at the electrical switchboard. In projects where the UPS or mains is backed up by a generator, it is recommended that it is tested as well. Upon resumption of power, verify that the AV system resets automatically to the control system start-up condition.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Report any devices that maintain state, and do not reset to the default start condition.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	ELEC-108
Verification Item	Power Monitoring	Date of Verification	
Verifier		Version	
Functional Category	Electrical		
Verification Phases	❑ Post-Integration		

Description
Verify power-monitoring equipment is working and reporting as defined in the project documentation. Power-monitoring equipment should be verified with a known electrical load where possible. If power-monitoring data is being collected for an energy management system, connectivity with the system should be verified.

Inputs
Identify power monitoring system within AV system and any external energy management or monitoring systems connected to the AV system. Calculate the applied load (if no test load available).

Tests, Procedures, and Equipment
1. Connect a known electrical load (e.g., a load bank or fixed power heater) to the power system.
2. Verify that the correct value is read on the meter.
If this is not possible, assess the connected load by gathering manufacturers' data for connected equipment, and check that the meter reads accordingly. This method is less exact because some equipment loads will vary under different conditions (e.g., amplifiers).
If the power monitoring system is connected to an energy management or other data collecting system, then check connectivity to that system. Again, apply a known load to the distribution system, and check the remote monitoring system to see that the correct value is being reported.

Metrics
N/A

Outputs
❑ Pass ❑ Fail

Notes
A more comprehensive reporting, providing a record of the tests undertaken and any recorded values against test loads, would be beneficial.

Sample Information Technology Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-100
Verification Item	Content Delivery Network	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		

Description
Verify that the content delivery network (e.g., digital signage) is in place and provides the required connectivity for the required audio, video, and control systems. Verify that all required content licensing has been acquired.

Inputs
The following inputs should be in place for this test: 1. Shared or dedicated AV network, including wireless networks (e.g., 802.11, ZigBee, Bluetooth, DECT) 2. Digital signage, media, AV inputs and IPTV content for distribution 3. Digital Rights Management (DRM) servers and licenses acquired 4. Conditional Access Modules (CAMs) acquired from the service provider 5. Set-top boxes acquired from the service provider 6. Headend installed

Tests, Procedures, and Equipment

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale

Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using specialist protocol analyzers to review bit error rates, packet loss, and processing and timing issues is recommended. Networks should also be reviewed for their impact as part of related verification items IT-102 Network Bandwidth, IT-103 Network QoS (Quality of Service), IT-104 Network Security, and IT-110 Network Topology.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Note any visual or audio impairment against the ITU-R BT.500-13 scale.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-101
Verification Item	IEEE 802 Wireless Security	Date of Verification	
Verifier		Version	
Functional Category	Information Technology		
Verification Phases	☐ Pre-Integration ☐ System Integration ☐ Post-Integration		

Description
Verify that the wireless network is protected in accordance with the client/owner's information security policies from unauthorized access and provides the required connectivity for the audio, video, and control systems.

Inputs
The following inputs are required to test a preexisting network installation:

- Shared or dedicated AV 802 wireless network is in place with the required coverage.
- Wireless security is a vast area of expertise and covers issues such as intrusion detection, intrusion prevention, as well as authentication. Refer to *Wireless and Network Security Integration Design Guide* (CISCO, 2008) for more comprehensive treatment.

Tests, Procedures, and Equipment
Testing should verify that:

- The security scheme can be implemented with the AV equipment required to use the wireless network
- The wireless devices are compatible with the available wireless protocols
- The credentials supplied by the IT manager allow the device onto the wireless network

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Due to security issues, it is unlikely that the credentials would be documented in the operation and maintenance manuals. Security credentials may be updated on a regular basis to provide a higher level of security.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-102
Verification Item	Network Bandwidth	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	❑ Pre-Integration ❑ Systems Integration ❑ Post-Integration		

Description
Verify that the required network bandwidth is available for control, audio, video, and data as part of either a shared or a dedicated AV network.

Inputs
A paper-based check should be performed in the pre-integration phase to determine if a planned or existing network has the capacity to provide the required AV services.
As part of systems integration, once the network is completed, a live production test should determine the actual capacity of the network.
Some tests cannot be performed on a production or pre-production network. In these instances, such a test will only be a paper-based check that the network has the capacity.
Refer to Item IT-114 Network Performance Under Full Functional Load to determine the network's ability to deliver services under stress.

Tests, Procedures, and Equipment
Testing procedure should include:
▪ Verifying that the network has been installed and configured for use
▪ For shared networks, verifying with the IT manager in the case of an existing or new network that invasive testing can be conducted
▪ Where invasive testing can be conducted, configuring a server to run Netperf/Iperf/Jperf or similar software to determine the networks ultimate capacity
▪ Running tests over a weekly or monthly cycle to capture the peak load
▪ Verifying the results against the AV system requirements
Measurements should include:
▪ Latency (response time or RTT), measured with the Ping command
▪ Jitter (latency variation), measured with an Iperf UDP test
▪ Datagram loss, measured with an Iperf UDP test
▪ The bandwidth, measured through TCP tests

Metrics
N/A

Outputs
❑ Pass ❑ Fail

Notes
Note the network statistics and bandwidth.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-103
Verification Item	Network QoS (Quality of Service)	Date of Verification	
Verifier		Version	
Functional Category	Information Technology		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that the required Quality of Service (QoS) is in place for audio, video, and data as part of either a shared network or a dedicated AV network.			
Inputs			
The network has been installed and configured for use.			
Tests, Procedures, and Equipment			
To perform the test: ▪ Review the network configuration to verify that the required QoS scheme is in place. ▪ Use IT-114 Network Performance Under Full Functional Load to verify that the QoS is performing.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Note the QoS scheme and traffic marking.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-104
Verification Item	Network Security	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		

Description
Verify that the shared or dedicated network is secure as defined in the project documentation and accessible to suit the required audio, video, and control systems.

Inputs
A paper-based check should be performed in the pre-integration phase to determine if a planned or existing network will be exposed, generally by way of an IT risk assessment.
Typically, network penetration testing is run by a specialized company to ensure the security of the organization's information systems.
In many cases, information assurance or internal security departments require a sample of network-connected equipment well in advance of deployment to perform security analysis on these devices.

Tests, Procedures, and Equipment

Active Testing

Active testing involves direct interaction with the component being tested for security vulnerabilities. This could be low-level components such as the TCP stack on a network device, or it could be components higher up on the stack (e.g., the web-based interface used to administer such a device). There are two distinct ways to interact with the target component: automated and manual:

- Automated testing utilizes software to interact with a target, examine responses, and determine whether vulnerabilities exist based on those responses.
- Manual testing—As with any automated process or technology, the margin for error always exists. Instabilities in systems, network devices, and network connectivity may introduce inaccurate results during testing. It is always recommended to execute manual direct connections to each protocol or service available on a target system to validate the results of automated testing as well as to identify all potential attack vectors and previously unidentified weaknesses.

Passive Testing

Passive testing involves metadata analysis, which consists of inspecting the data that describes a file, as opposed to the file data itself, and traffic monitoring (the concept of connecting to an internal network and capturing data for offline analysis).

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-105
Verification Item	Telephony	Date of Verification	
Verifier		Version	
Functional Category	Information Technology		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that any required telephony connections to the AV system are in place and connectivity is verified.			
Inputs			
Contact the appropriate manager of the facility telephony systems to ensure the proper connection is available in the room(s). Ensure any VoIP connection ordered with the audio DSP is compatible with the building's telephony system. Telephony connections must be requested during the pre-integration phase and verified to be available prior to testing. Any connections to a VoIP system may require network address information for the endpoints.			
Tests, Procedures, and Equipment			
It is important to check the voltage. It is also important to check the line voltage during peak loads of the day as voltage will fluctuate due to call volume in the telephone system. Weak voltage will cause a breakdown in a connected call as the voltage goes lower than a standard phone adapter in an AV system can detect. A standard phone voltage meter should be used to verify the quality of the analog breakout. VoIP connections should be treated like the network connection they are. Preplanning to include the AV connections to the call management systems prior to testing is necessary. Network or telephony management may need to provide network addresses for the AV devices. Any test should include calls to a bridge system if one is present within the client's network.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Note the configuration.			

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	IT-106
Verification Item	Unified Communications	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	❑ Pre-Integration ❑ Systems Integration ❑ Post-Integration		

Description
Verify that any connections to IT-based unified communication applications that will interface with the AV system have been planned for and integrated.

Inputs
Ensure proper compatibility and connection to the UCC system. Some tests will simply review proper operation within the solution environment, while others will require network testing plans and equipment. It would be important to determine well in advance who will be responsible for each part of the verification and testing.

Tests, Procedures, and Equipment
Examples of items to consider are: ▪ SIP licensing—Provision of adequate licensing for the AV systems. ▪ User licensing—Provision of adequate user licensing within the AV system (i.e., webcams or conference phones). ▪ Hardware interfaces—Interface products used to connect systems to webconferencing and enterprise conferencing, touchpanels, and DSP audio SIP interface modules.

Metrics
N/A

Outputs
❑ Pass ❑ Fail

Notes
Note the configuration.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-107
Verification Item	AV IP Address Scheme	**Date**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	☐ Pre-Integration ☐ Systems Integration		
Description			
Verify and document that all network-connected equipment has the correct IP address, subnet mask, hostname, and gateway configuration as defined in the project documentation.			
Inputs			
All IP addresses, subnet masks, and gateway configurations are recorded.			
Tests, Procedures, and Equipment			
A spreadsheet of all the recorded IP addresses, subnet masks, and gateway configurations should be created. All AV devices that have to communicate with each other are most efficient when they are in the same subnet or VLAN. Verify that each AV device in the system is configured to the correct VLAN. Various software tools like NetScanner and SoftPerfect Scanner can be used to get the list of all the IP address and subnet mask information for all network devices.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Note the IP address listing.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-108
Verification Item	IEEE 802 Wireless Networks	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	☐ Pre-Integration ☐ Systems Integration		
Description			

Verify that the wireless network configuration is correct and valid (e.g., channel no., SSID, TX power) in defined areas of use as defined in the project documentation.
Verify that there is adequate channel separation between any client wireless networks that are required to co-exist in the same area.

Inputs

The wireless network is installed and configured for use.

Tests, Procedures, and Equipment

Testing should verify:
- The AV equipment requiring to use the wireless network
- The wireless devices are compatible with the available wireless protocols
- The credentials supplied by the IT manager allow the device onto the wireless network
- If credentials are implemented by the AV contractor, they follow the owner's standards or, in absence, any national information security standards so as to not leave these systems exposed

Each system using the wireless network should be tested independently. Refer to tests in WL-100 Wireless Audio Systems Operation, WL-101 Wireless Control Systems Operation, and WL-103 Wireless Video Systems Operation. Following independent system verification, all wireless controls systems should be run simultaneously to check for interference. Typically, built-in tools will provide signal strength and assist with the diagnosis of noise.

If issues are detected, it is recommended that a second level of testing is performed using a spectrum analyzer.

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.

Check that all control signals are being received and all commands executed reliably with no intermittent control dropouts.

Metrics

N/A

Outputs

☐ Pass ☐ Fail

Notes

Also note the configuration.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-109
Verification Item	PoE (Power over Ethernet	**Date of Verification**	
Verifier		**Version**	
Functional Category	IT		
Verification Phases	❑ Pre-Integration ❑ Systems Integration		

Description
Verify that PoE (Power over Ethernet) devices are supplied with correct power required for normal device operation. Verify under practical conditions that the switch providing PoE has the capacity to power all of the devices that are connected to it.

Inputs
The system is fully installed and functional.

Tests, Procedures, and Equipment
A simple test is to verify that the powered devices are on and operating normally when plugged into the switch. Certain network test devices provide a load to the switch and display the watts that are drawn from the switch. This test provides data needed to verify that the actual load isn't more than the switch is rated for. The Fluke LinkRunner AT Network Auto-Tester provides this kind of power loading. The POE1000 and POE1000il from Byte Brothers also provide loading of ports, and the il version can be used inline with the AV device to show exactly how many watts are being drawn by the device. Use a test device that provides readout of the wattage supplied by the port and connects at the AV device location. Record the wattage available at the AV device.

Metrics
N/A

Outputs
❑ Pass ❑ Fail

Notes
Provide a spreadsheet showing all AV devices requiring PoE. Optionally, list the wattage provided to the device.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-110
Verification Item	Network Topology	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	❑ Pre-Integration		
Description			
Verify that the network for audio, video, and control is of a suitable topology to support the services to be delivered as defined in the project documentation.			
Inputs			
This item should verify that the following is provided: ▪ A network design that provides suitable headroom above the required bandwidth ▪ A QoS scheme that can provide real-time services when congested ▪ Minimal network hops ▪ Low latency ▪ Security, but also all logical port connectivity ▪ Performance monitoring tools to enable management ▪ VLANs assigned per service (i.e., IPTV, control, video, audio)			
Tests, Procedures, and Equipment			
To complete this verification: ▪ Review the documentation detailing the network topology if the network is provided by others or is preexisting. ▪ Review related verification items—IT-102 Network Bandwidth, IT-103 Network QoS (Quality of Service), and IT-114 Performance Testing Under Full Functional Load.			
Metrics			
N/A			
Outputs			
❑ Pass ❑ Fail			
Notes			
Note the topology.			

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	IT-111
Verification Item	Application Integration	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that the AV and control systems have been integrated and have been fully configured with headend software, including monitoring and asset management; databases; web-based front ends; digital signage software and systems; content generation and distribution platforms; and appliances as defined in the project documentation.

Inputs
This item should verify that the following is provided:

- Servers are in place according to the recommended specifications and commissioned with the server operating system, supporting application components, and the main application to be integrated.
- Separate SQL servers are in place and configured according to the applications' requirements, including multiple drives where required and database creator privileges.
- Applications are installed with administrator privileges.
- The email server is set up and configured with accounts and calendars for the applications server's usage.
- Servers are integrated with Active Directory or single-domain architecture.
- Servers, workstation, connected control systems, and end-points are correctly configured on the network.
- SMTP authentication is conducted via appropriate network SMTP credentials.
- Firewalls and access control lists are set to permit the bidirectional flow of data on the default application ports.
- A backup strategy is in place, which may include nightly backups of data files.

Tests, Procedures, and Equipment
Verify all systems mapping (e.g., room and devices to the rooms, screens/endpoint devices to the graphic location). Step through all system functionality (e.g., room scheduling, media scheduling, fault simulation, monitoring, reporting).

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Note the configuration faults.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-112
Verification Item	Enterprise Management Tools	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	☐ Post-Integration		

Description
Verify that enterprise management tools such as central monitoring client/server or web-based applications have been installed and connected to all systems they are required to monitor or control as specified in the project documentation.

Inputs
The system is fully installed and functional.

Tests, Procedures, and Equipment
List all systems, devices, or tools requiring remote management across the enterprise network. Each item shall be listed and then tested from the remote application or server. Verify all connected codecs and the call status of the codecs. Exact testing is dependent on the type of enterprise system defined in the system documentation.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Provide a list of enterprise management items.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-113
Verification Item	Identity Management Plan	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	☐ Post-Integration		

Description
Verify that all systems authentication credentials are configured correctly. Any temporary credential used during system installation and commissioning should be removed.   User and group authentication and authorization are verified based on the requirements from the project documentation.   Connectivity with the central directory, database, or other identity authority should be verified.

Inputs
The system is fully installed and functional.

Tests, Procedures, and Equipment
Test the logins using known and approved login credentials to verify connection to the credential database, whether on a remote server or native to the device or application. These tests should be performed directly with or guided by the client's IT security representative.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Provide a signed statement by the client's IT security representative or project representative confirming that the identity management verification shows the proper credentials are created or available through the AV system referenced in the documentation. Such a statement may cover multiple systems in the same AV project (e.g., security cameras, digital signage software, audio DSP devices).

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-114
Verification Item	Network Performance Under Full Functional Load	Date of Verification	
Verifier		Version	
Functional Category	Information Technology		
Verification Phases	☐ Post-Integration		

Description
Verify that the network can provide the required operational performance to carry control, audio, video, and data under production load and at times of peak production load (refer to IT-102 Network Bandwidth).

Inputs
Verify that network has been installed and configured for use. For shared networks, verify with the IT manager in the case of an existing or new network that invasive testing can be conducted.

Tests, Procedures, and Equipment

Qualitative performance testing should be completed for each service using the network, including (but not limited to):

- Control systems
- Videoconferencing
- IPTV
- Video streaming
- SIP-based audioconferencing
- Audio over the network (e.g., public address)

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale

Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using specialist protocol analyzers to review network bandwidth, bit error rates, packet loss, and processing and timing issues is recommended.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Note the statistics.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	IT-115
Verification Item	Remote Access	**Date of Verification**	
Verifier		**Version**	
Functional Category	Information Technology		
Verification Phases	❑ Post-Integration		

Description
Verify that remote access to AV and IT systems is configured as defined in the project documentation.

Inputs
The system is fully installed and functional.

Tests, Procedures, and Equipment
List the specific systems requiring remote access per the documentation (i.e., control system, audio DSP, VC codec). List the type of remote access being used (e.g., VPN, a computer's remote desktop control).   From a computer outside the LAN/WAN of the system under test, verify a connection can be made to each system or device listed above.

Metrics
N/A

Outputs
❑ Pass ❑ Fail

Notes
The documentation should show the specific systems requiring remote access and the method used to gain access to the devices listed.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #		IT-116
Verification Item	Remote Management	**Date of Verification**		
Verifier		**Version**		
Functional Category	Information Technology			
Verification Phases	☐ Post-Integration			

Description
Verify that remote management tools such as virtual touchpanels, internal web applications, or manufacturer's applications are configured and functional as required by the project documentation and/or manufacturer's specification.

Inputs
The system is fully installed and functional.

Tests, Procedures, and Equipment
The contractor shall list all systems, devices, or tools requiring remote access from within the IT network (LAN or WAN). Each item shall be listed and then tested from the remote application. For instance, control system web-based touchpanel emulation files shall be shown to work from a remote PC within the facilities network. Exact testing depends on the type of remote access defined in the system documentation.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Provide a list of remote management items.

Sample Operations and Support Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	OP-100
Verification Item	Software	Date of Verification	
Verifier		Version	
Functional Category	Operations and Support		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that all control programming code, DSP configuration files, and any other associated software have been provided as defined in the project documentation.			
Inputs			
All equipment is installed and functional.			
Tests, Procedures, and Equipment			
List by room or location all devices that require specific software or programming. Provide that list along with copies of the files to the owner. The list should have a place where the customer can sign off that they have received the software. Examples include: ▪ Uncompiled control system code (depending on the specification) ▪ DSP programming software and the actual files specific to the project ▪ Configuration files for equipment like network switches, and video scalers ▪ Digital signage layouts or templates ▪ Any other software listed in the specification documents The primary task is to verify that solutions exist and that, if solutions are provided, they follow the project documentation.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Submit a list of all software with the signed documentation from the customer showing the software was received.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	OP-101
Verification Item	Battery Management Plan	**Date of Verification**	
Verifier		**Version**	
Functional Category	Operations and Support		
Verification Phases	☐ Pre-Integration		

Description
Verify that a battery management plan has been completed and supplied in the project documentation package to owner.

Prerequisite Conditions
The system is fully operational.

Tests, Procedures, and Equipment
A battery a plan should consider: ▪ Equipment requirements—Details of batteries required for all equipment (i.e., AA 9 V lithium ion proprietary) ▪ Special battery replacement (i.e., for button cells in control systems) ▪ Sources of spare batteries ▪ Guidance on typical battery life for expected usage patterns ▪ Battery management routine (e.g., regular replacement requirements) ▪ Battery charging procedures ▪ Battery disposal or recycling (depending on the region) Review the owner's project documentation package to verify that there is an adequate battery plan.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	OP-102
Verification Item	Content Management Plan	Date of Verification	
Verifier		Version	
Functional Category	Operations and Support		
Verification Phases	☐ Pre-Integration		

Description
Verify there is a plan for managing the content to be delivered by the AV systems, including the means to create content and update content when new information needs to be conveyed.

Inputs
N/A

Tests, Procedures, and Equipment
A content management plan typically identifies the following:

- Persons responsible for creating the content
- Methods of content delivery (format and medium)
- Methods of cataloguing and referencing the content
- Persons responsible for loading the content if it is file based
- Persons responsible for updating the content

In many instances, a content management plan is not generated, and the system is handed over without content, which is not ideal. The primary task is to verify that if a plan exists and that the solution provided follows the plan.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	OP-103
Verification Item	System Content Provided	Date of Verification	
Verifier		Version	
Functional Category	Operations and Support		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that any owner, vendor, or third-party-produced system content that is required for operations as defined in the project documentation has been supplied, loaded, and tested in the completed AV system.

Inputs
All AV systems are installed and all content is loaded or ready for playback.

Tests, Procedures, and Equipment
Obtain the list of content material from the content management plan.
If the content management plan does not exist or is incomplete then the contractor may encourage the client/necessary parties to create it.
If the content creation responsibility lies with the AV contractor, it is recommended that a content signoff procedure is put in place.

Outputs
☐ Pass ☐ Fail

Notes
The notes section should reflect the responsibility for and the party tasked with updating any content. Normally, the contract or project documentation covers these responsibilities and the parties involved. This should be noted for easy future reference.

Sample Physical Environment Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-100
Verification Item	Divisible Spaces	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that the divisible spaces provide the functionality specified as defined in the project documentation.			
Inputs			
All systems are installed.			
Tests, Procedures, and Equipment			
Test the operation of each portion of the divisible space separately. Then, test the operation of the space in combined mode. Verify that all features are fully operational as specified in the project documentation.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-101
Verification Item	Human Factors, Usability, and Ergonomics	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	❑ Pre-Integration ❑ Systems Integration, ❑ Post-Integration		

Description
Verify that ergonomics and usability elements for audience and system users are installed and configured as defined in the project documentation.

Inputs
Examples of elements that should be verified in accordance with project documentation are: ▪ Accessibility of inputs, so the users are not required to search for a place to plug in a mobile or portable device ▪ Providing guest facilities so software does not need to be installed to use in-room equipment, such as wireless presenters ▪ Providing presenters a with view of their presentation content while facing the audience so they do not need to bend down or look away ▪ Providing self-view and camera presets or automated pan-tilt-and-zoom (PTZ) facilities for videoconferencing while facing the camera to maintain eye contact ▪ Optimum camera locations to maintain eye contact and not have the far end positioned and looking down or up relative to the near end ▪ Providing height adjustment to lecterns, microphones, and other devices to suit the users' height range ▪ Designing touchpanels to enable all key room setup and videoconferencing endpoints to be applied with a maximum of only three touches/clicks and a small range of movement

Tests, Procedures, and Equipment
Verify that considerations have been made for the end user's ease of physical access to system operational controls and all AV equipment requiring direct user operation and allow convenient access to system inputs/outputs in support of portable equipment supplied by end users. These ergonomic considerations should take into account use by both able-bodied users and users with special needs.

Metrics
N/A

Outputs
❑ Pass ❑ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-102
Verification Item	Lighting	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		

Description
Verify that the lighting systems are suitable for each type of application (e.g., videoconferencing, presentation, broadcast, performance) as defined in the project documentation. This verification item should require a metric to be verified.

Inputs
Lighting and AV control systems are operational and ready to be commissioned.

Tests, Procedures, and Equipment
Testing consists of using an appropriate lightmeter (spot photometer or illuminance meter) to take measurements as indicated in the publication or standard referenced in the project specifications.

Metrics
Lighting metrics (luminance and illuminance) vary depending on the application. This section defines two common applications and proposed metrics: task-based lighting and videoconference lighting.

Task-Based Lighting

People reading or analyzing content on a tabletop surface. There must be enough light falling on the table for people to comfortably interpret what they are seeing (IESNA's *Lighting Handbook*):

- Classroom table surface 300 to 500 lux
- Lecture hall 400 lux
- Conference rooms 300 lux

Videoconference Lighting

People in one location are visually interacting with others in at least one remote location. In this environment, how people appear on camera is critical. It's not entirely about the light levels produced in the room, but the image produced by the camera. This environment is very complex and requires significant infrastructure and lighting design. Here are a variety of metrics to consider from IESNA's *Fundamentals of Lighting for Videoconferencing*, page 9:

Participants (vertical illuminance) 300 to 500 lux

- Walls 200 to 400 lux
- Display spill light 200 lux or less for direct view, 150 lux or less on rear screen projection systems, 50 lux or less on front projection systems
- Lamp color temperature 3000 to 3500 K
- Wall finishes 40–60% reflectance
- Table surface 20–60% reflectance

Outputs
☐ Pass ☐ Fail
Measurement Result:

Notes
Create a floor plan indicating furniture placement and locations where measurements were taken. Provide a document listing the results.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-103
Verification Item	Vibration	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that the physical environment is suitable for the intended AV systems in relation to all sources of vibration affecting stability of equipment such as videoconferencing cameras, document cameras, and fixed screen and projector locations.			
Inputs			
Projectors, cameras (e.g., videoconferencing document, monitoring), screens (e.g., rear projection, ceiling), and mirrors can be affected by vibration.			
Tests, Procedures, and Equipment			

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale

Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using low-frequency vibration analysis with an accelerometer is recommended. Quantitative testing of less than 100 micrometers/second (μm/s), root mean square (RMS) as measured in 1/3 octave bands over the 1 Hz-to-1 kHz frequency range.

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent vibration issues and during times all systems are running.

Testing should include scenarios where cameras are fully zoomed in to accentuate vibration effects.

Metrics
N/A
Outputs
☐ Pass ☐ Fail
Notes
Note visual qualitative results and any periodic vibration occurrences (e.g., passing trains, results during a generator test, results when the air-conditioning plant starts up).

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InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	PHYSE-104
Verification Item	Backing/Blocking/Framing	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		

Description
Verify that installed backing, blocking, and framing meets project documentation requirements and industry standards for installation means and methods.

Inputs
Project documents should include: ▪ Project design drawings and narrative documents ▪ Approved submittals for materials for backing/blocking/framing by general contractor ▪ Approved submittals for AV equipment and mounting hardware submitted by AV integrator Onsite installation of all backing/blocking/framing should be complete.

Tests, Procedures and Equipment
Tests and procedures should include: ▪ Comparison of the project design documents to the submittal documents of mounting hardware, AV equipment, and intended use for compatibility ▪ Visual inspection of final backing, blocking, and framing installation

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-105
Verification Item	Clean Building Handover	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		

Description
Verify that the area is clean and dust-free and suitable for equipment installation and that no further work is planned that will release contaminants into the AV equipment area. Verify that the area released is isolated from any areas not yet released.

Inputs
Spaces where AV equipment is to be installed (i.e. equipment rack closets, rear projection rooms, accessible spaces) must be fully constructed and have been cleaned and prepared for the installation of the AV system components.

Tests, Procedures, and Equipment
Visually inspect the areas where the AV equipment is to be installed. Verify that it has been cleaned, vacuumed, and dusted.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-106
Verification Item	Coordinated Construction Elements	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		

Description
Verify that the elements including but not limited to spatial requirements and building services required by the AV system that are coordinated with other disciplines have been provided per the project documentation.

Inputs
Walls, ceilings, floors, infrastructure (such as conduit/containment, floor boxes, and ceiling tile supports) and other similar building elements are fully constructed, supported, and prepared for the installation of the AV system components. Lighting and AV control systems are operational and ready to be commissioned. Electrical, HVAC, communications and other similar building systems and/or services have been installed and are fully functional.

Tests, Procedures, and Equipment
Visually inspect all building systems required for the installation of the AV system as defined in the project documentation. Compare the results with engineering drawings and specifications and document any discrepancies.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-107
Verification Item	Device Enclosures	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		
Description			
Verify that device enclosures accommodate the intended device and that all necessary environmental controls (e.g., heating, cooling, humidity) are incorporated into the enclosure as defined in the project documentation.			
Inputs			
The system is fully installed and functional.			
Tests, Procedures, and Equipment			
A visual inspection of all AV equipment shall be performed. A list of the equipment with three columns (Fit, Usability, and Environmental) shall be made and each item checked off the list showing that it meets the project documentation's specifications.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Provide an equipment list with three additional columns showing that the device passes the three criteria.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-108
Verification Item	Finishes	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		

Description
Verify AV equipment, furniture, fixtures, and accessories against the project documentation.

Inputs
Samples or colors are submitted to the architect or owner and at completion of installation.

Tests, Procedures, and Equipment
List all devices, equipment, or surfaces that require a sample or color choice approval. Provide documentation showing colors or samples were submitted for review. Provide documentation showing the colors or samples that were approved.
After the equipment is installed, perform a visual verification of each item by comparing the item to the sample material that was submitted. Indicate on the list of items that each item passed the visual inspection.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Provide a list of all devices and the date they were approved by visual inspection.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-109
Verification Item	Floor Boxes/Wall Boxes/Ceiling Boxes	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		

Description
Verify that installed floor, wall, and ceiling boxes meet project documentation and regulatory authority requirements.

Inputs
Perform a review at multiple stages (see below). Items to check include proper device, proper fit (e.g., level, plumb, square), proper location, and proper finish.

Tests, Procedures, and Equipment
Review all floor, ceiling, and wall boxes to verify that they meet the specification for size, finish, and location. This should be reviewed at the following stages:
▪ Submittal phase
▪ If installed by another trade, when product arrives on site
▪ After the installation of the enclosures/devices
▪ After the installation of any equipment, plates, or terminations within the enclosures

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
On a plan or elevation view, check off or initial each device or enclosure as having passed the review and include the date of review.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-110
Verification Item	HVAC Commissioned	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		
Description			
Verify that the HVAC system has been tested and balanced prior to completing Verification Items AP-112 Acoustical Ambient Noise and AP-116 Audio Level Exceeds Background Noise Level.			
Inputs			
All systems are installed.			
Tests, Procedures, and Equipment			
Start up the HVAC system and verify that the system is functioning per the HVAC specifications. Document any issues discovered.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-111
Verification Item	HVAC Operations	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		
Description			
Verify that the HVAC system has begun continuous operations in advance of equipment operations.			
Inputs			
All systems are installed.			
Tests, Procedures, and Equipment			
Verify with the HVAC installer and the owner's representative that the system has been started and is functioning per the HVAC specifications.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-112
Verification Item	Structural Mounting	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Pre-Integration		
Description			
Verify configuration and compatibility of structural accommodations and all mounting hardware based on the intended application. All equipment mounting hardware shall be installed in the manner specified by the hardware manufacturer.			
Inputs			
All equipment-mounting hardware is installed in the manner designated by the hardware manufacturer or as directed by the project's authority having jurisdiction (AHJ) for structural design and implementation oversight.			
Tests, Procedures and Equipment			
Compare submittal documents with the mounting hardware, AV equipment, and intended use for compatibility. Complete a visual inspection of the final installation.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

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Project Name		Verification Item #	PHYSE-113
Verification Item	Protection of Installed Equipment	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Environment		
Verification Phases	☐ Systems Integration		
Description			
Verify that all elements of the AV system are free of damage.			
Inputs			
All rack-mounted equipment as well as devices and components are installed within the space systems.			
Tests, Procedures, and Equipment			
Visually inspect all AV equipment for damage. Document any damage discovered.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSE-114
Verification Item	Accessibility	Date of Verification	
Verifier		Version	
Functional Category	Physical Environment		
Verification Phases	☐ Post-Integration		
Description			
Verify that all systems are accessible in accordance with regulatory requirements.			
Inputs			
All user controls and other devices requiring user interaction (i.e., control panels, media players, input/output devices) are installed.			
Tests, Procedures, and Equipment			
Visually verify that all equipment intended for user interaction has been installed per established codes and regulations.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

Sample Physical Installation Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-100
Verification Item	Cable Containment/Conduit	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Installation		
Verification Phases	☐ Pre-Integration		
Description			
Verify that installed containment/conduit capacity and routes meet project documentation requirements, industry standards, and regulatory requirements for installation means and methods.			
Inputs			
All wiring is installed and terminated per system specifications.			
Tests, Procedures, and Equipment			
Visually verify the following as pass/fail: ▪ Cables are routed through conduit based on different signal types. ▪ Power and AV wiring are correctly isolated from each other. ▪ An example based on U.S. codes for conduit fill includes: ▪ A single cable in a conduit shall be 53% of the conduit. ▪ Two cables shall be 31% of the conduit. ▪ More than two cables shall be 40% of the conduit.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Note each room or location as pass or fail based on the visual inspection of the cable conduit or raceway.			

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-101
Verification Item	AV Rack Airflow and Temperature Performance	Date of Verification	
Verifier		Version	
Functional Category	Physical Installation		
Verification Phases	☐ Systems Integration ☐ Post-Integration		

Description
Verify that the AV rack(s) provides the airflow as required in the project documentation. Verify that the temperature in the AV rack has been measured and is within tolerances defined by manufacturers' guidelines and the project documentation. This verification item shall require a metric to be verified.

Inputs
Systems Integration Phase: AV equipment racks are installed to final location. **Post-Integration Phase:** HVAC systems are commissioned and operational.

Tests, Procedures, and Equipment
The following tests and their associated procedures are required to complete this verification item: ▪ Review the airflow and ventilation provision (e.g., fans, vents, supply air) actually provided against the stated requirements from the project documentation. ▪ Measure the surface temperature at six locations—front and rear surfaces at top one-third, middle one-third, and bottom one-third of rack—and record the reported operating temperature of any operational equipment. A simple temperature-probe measuring instrument is all that is required for this test. If a time-based temperature recorder is available (or even a maximum/minimum logger), it would be beneficial to run a test over a 24-hour period to account for HVAC operation variation.

Metrics
In the absence of project documentation and/or specific manufacturer requirements, the thermal gradient performance of the rack should operate so that each piece of equipment remains below 24.5 °C (85 °F).

Outputs
☐ Pass ☐ Fail Record results for each measurement position.

Notes
Lower extremes of operating temperature may be required if the installation is undertaken in a cold location.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-102
Verification Item	Equipment Security	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Installation		
Verification Phases	☐ Systems Integration ☐ Post-Integration		
Description			
Verify that equipment is secured as defined in the project documentation. Verify that all security systems, devices, and manufacturer security accessories are installed and verified to be operating as defined in project documentation. Verify that keyed devices have been keyed as defined in the project documentation and devices requiring configuration have been configured as defined in the project documentation and are verified to be operating within specification.			
Inputs			
All systems are installed.			
Tests, Procedures, and Equipment			
Visually inspect all security hardware and physically test locks for proper functionality. Refer to specifications for project-specific requirements and document any non-conformance.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	PHYSI-103
Verification Item	AV Equipment Labeling	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Installation		
Verification Phases	☐ Systems Integration		
Description			
Verify that all AV equipment has been labeled in accordance with the requirements of the project documentation. All labeling must be consistent, durable, accurate, and visible without dismantling of sub-assemblies.			
Inputs			
All equipment items are installed.			
Tests, Procedures, and Equipment			
Visually inspect the installed equipment using the appropriate level- and/or angle-measuring device. Refer to the specifications for project-specific requirements and document any non-conformance.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		**Verification Item #**	PHYSI-104
Verification Item	Plumb and Level/Square	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Installation		
Verification Phases	☐ Systems Integration		

Description
Verify that all AV equipment has been installed, aligned, or angled correctly as defined in the project documentation. Level and plumb are the default requirement unless particular angles or other alignments are defined in the project documentation.

Inputs
All devices are installed.

Tests, Procedures, and Equipment
Visually inspect the installed equipment using the appropriate level- and/or angle-measuring device. Refer to the specifications for project-specific requirements and document any non-conformance. Measurement equipment varies from the basic spirit level (bubble level) to laser and electronic type levels that also can provide angle measurements. The installation activity and requirements would dictate the device required.

Metrics
N/A

Outputs
☐ Pass ☐ Fail Measurement Result:

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-105
Verification Item	Site Security	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Installation		
Verification Phases	☐ Systems Integration		

Description
Verify that all elements of the AV system are free from loss, damage or tampering.

Inputs
All specified devices and accessories are present.

Tests, Procedures, and Equipment
Visually inspect all AV equipment for damage or tampering. Inventory all equipment to verify that all specified devices and accessories are present and accounted for. Document any missing equipment.
Take special precautions to prevent construction and unintentional damage. An example would be to use temporary coverings and wraps to protect finishes from bumps and scratches.
Ensure that the spaces where the AV equipment is installed are properly locked.
Site security should ensure that the construction site is secured and not accessible to the public and is controlled to a limited range of known personnel for auditing in case of theft. Each space where the AV will be installed should have controlled access.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

InfoComm 10-2013 Verification Test Sheet

Project Name		PHYSI	PHYSI-106
Verification Item	AV Equipment Located Per Project Documentation	Date of Verification	
Verifier		Version	
Functional Category	Physical Installation		
Verification Phases	☐ Post Integration		

Description
Verify that AV equipment is installed at the location and/or in the rack or enclosure as defined in the project documentation. Equipment is installed per the elevation or other specification provided by the project documentation or the manufacturer's specification.

Inputs
The equipment is located as specified in the project documentation.

Tests, Procedures, and Equipment
Visually verify the following as pass/fail: ▪ Using the elevation drawings, measure actual AV equipment locations against measurements shown on the drawings. Highlight or check each item as correct or incorrect. ▪ Using plan drawings, verify the physical location of the device, rack, AV furniture, and so on. Highlight or check each item as correct or incorrect. ▪ Using the reflected ceiling plan, verify the physical locations of the device, speaker, projector, and so on. Highlight or check each item as correct.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Final documentation shall consist of a copy of the elevation, plan, and reflected ceiling plan drawings and any other pertinent drawing. Each piece of AV equipment shall have a check or highlighting noting that the device has passed or failed the location verification. Specifically with ceiling mounted equipment, verify any conflicts between the AV equipment and other, non-AV equipment. In some cases, the AV equipment may be located according to the documentation, but, due to coordination issues, there may be a conflict. An example would be a ceiling speaker blocked by a large lighting fixture.

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-107
Verification Item	AV Rack Cleanliness	Date of Verification	
Verifier		Version	
Functional Category	Physical Installation		
Verification Phases	☐ Post-Integration		

Description
Verify that all components installed in AV equipment racks are free from dirt, dust, water, or any other element that would compromise the performance and/or longevity of the AV system.

Inputs
The AV equipment racks are installed.

Tests, Procedures, and Equipment
Visually inspect all AV equipment for dust, dirt, and water.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Document any detrimental items discovered.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-108
Verification Item	Non-End-User Controls Protection	**Date of Verification**	
Verifier		**Version**	
Functional Category	Physical Installation		
Verification Phases	☐ Post-Integration		
Description			
Verify that installed items with user-facing controls that are not intended for end-user access have been covered, disabled, or otherwise secured to prevent end-user operation.			
Inputs			
All wiring is installed and terminated per system specifications.			
Tests, Procedures, and Equipment			
If a list of equipment is not provided in the documentation indicating which devices should be secured from end-user adjustment, create such a list. Check that each item on the list is secured to prevent changes to the equipment beyond what is expected in a normal use scenario for the system.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-109
Verification Item	Optical Components Cleanliness	Date of Verification	
Verifier		Version	
Functional Category	Physical Installation		
Verification Phases	☐ Post-Integration		
Description			
Verify that all optical components, such as lenses and mirrors, are free from dirt, dust, damage, or markings that would compromise the optical performance of those system components.			
Inputs			
All systems are installed.			
Tests, Procedures, and Equipment			
Visually inspect all lenses, mirrors, and other optical components for: ▪ Fingerprints ▪ Dust and dirt ▪ Scratches ▪ Distortion ▪ Cleaning residue ▪ Alignment and focus			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Document any detrimental items discovered.			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-110
Verification Item	Handling of Accessories Otherwise Undefined	Date of Verification	
Verifier		Version	
Functional Category	Physical Installation		
Verification Phases	☐ Closeout		

Description
Verify that all items that may have been pre-packaged with primary system equipment but which have no documented planned use in the AV system(s) are managed in accordance with the project documentation.

Inputs
All wiring is installed and terminated per system specifications.

Tests, Procedures, and Equipment
Provide the end-user documentation showing the types of accessories and method of transferring them to their possession. Have the end user sign the documentation acknowledging receipt of the equipment. If no specific documentation exists, create a basic equipment inventory that the owner can sign. It can be a straightforward document. An example would be, "27 projector remotes, 10 LCD TV remotes, 12 video receiver power supplies, 4 wireless microphones, and miscellaneous rack hardware."

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	PHYSI-111
Verification Item	Turnover of Accessory System Elements	Date of Verification	
Verifier		Version	
Functional Category	Physical Installation		
Verification Phases	☐ Closeout		

Description
Verify that any equipment that may be considered "portable" and/or otherwise not specifically incorporated into the installed AV system(s) has been set up, configured, and tested.

Inputs
All systems are installed.

Tests, Procedures, and Equipment
Set up the equipment as it is intended to be used in the system documentation. List the equipment, where it was tested, and whether it performs as outlined in the system documentation. Since these systems could be many different types of equipment, other verification items may be used to complete this test. A portable projector and screen should be tested under VP-108 Display Brightness Uniformity and VP-109 Projected Image Contrast Ratio.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
List any applicable verification items that apply to the accessory system or portable equipment, for example, "Ballroom audio system, 6 bodypack wireless transmitters, 6 wireless lapel microphones, and 6 sets of rechargeable batteries tested and stored in room 324 equipment rack microphone drawer."

Sample Serviceability Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		**PHYSI**	SERV-100
Verification Item	Access Panels	**Date of Verification**	
Verifier		**Version**	
Functional Category	Serviceability		
Verification Phases	☐ Pre-Integration ☐ Systems Integration		
Description			
Verify that any access panels that have been installed to provide access to any type of AV equipment are properly sized and positioned as detailed in the project documentation.			
Inputs			
All equipment or wiring behind access panels is installed and functional.			
Tests, Procedures, and Equipment			

Visually verify the following as pass/fail:
- Is the access panel located as specified in the drawings?
- Can buttons, wiring, status lights, panels, or other controls be easily accessed through the opening or door?
- Can connections be made to all jacks or connectors without obstruction?
- Is the access panel mounted plumb and level?
- If the enclosure holds equipment that may need to be replaced or removed for service, can it physically pass through the access panel opening?

Metrics

N/A

Outputs

☐ Pass ☐ Fail

Notes

Final documentation shall consist of a copy of the elevation drawings with each access panel highlighted or checked to show that it has passed the verification. If the panel does not pass the verification, notes shall be made referencing the reason why the access panel has failed.

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Project Name		Verification Item #	SERV-101
Verification Item	Ability to Maintain and Service Equipment	**Date of Verification**	
Verifier		**Version**	
Functional Category	Cable Management		
Verification Phases	☐ Post-Integration		
Description			
All equipment shall be accessible and capable of being maintained, serviced, cleaned or adjusted as necessary. All equipment requiring regular cleaning or maintenance shall be accessible without requirement for special equipment or tools that would disrupt the normal use of the facility and systems therein.			
Inputs			
All equipment is installed.			
Tests, Procedures, and Equipment			
Mounted equipment should be accessible for services to be adjusted or replaced. Adjustment points on devices should be accessible. Equipment in plenum areas should be identified and accessible for service.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		PHYSI	SERV-102
Verification Item	Input and Output Panel Accessibility	**Date of Verification**	
Verifier		**Version**	
Functional Category	Serviceability		
Verification Phases	☐ Post-Integration		
Description			
Verify that all input and output panels are accessible and meet all requirements for user access and placement.			
Inputs			
All I/O panels are installed an operational.			
Tests, Procedures, and Equipment			
Visually verify the following as pass/fail: ▪ Is the I/O panel located as specified in the drawings? ▪ For I/O panels located within an enclosure, can buttons or other controls be easily accessed through the opening or door? ▪ For I/O panels located within an enclosure, can connections be made to all jacks or connectors without obstruction? Each connector or jack shall be tested with the appropriate mating connector or cable for verification. ▪ Is the I/O panel mounted plumb and level?			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			
Final documentation shall consist of a copy of the elevation drawings with each I/O panel highlighted or checked to show that it has passed the verification. If the panel does not pass the verification, notes shall be made referencing the reason why the I/O panel has failed.			

InfoComm 10-2013 Verification Test Sheet

Project Name	Rack Clearance	Verification Item #	SERV-103
Verification Item		**Date of Verification**	
Verifier		**Version**	
Functional Category	Serviceability		
Verification Phases	☐ Post-Integration		

Description
Verify rack placement and use for physical stability in accordance with the project documentation and regulatory authority.

Inputs
All racks are installed.

Tests, Procedures and Equipment
The placement of the rack and the manner in which it is used should ensure physical stability. Further, ensure the rack placement allows safe and complete working access for technicians to perform upgrades and on-going servicing of the system.   **Moveable Racks**   Perform a visual inspection. Move racks in the intended manner and in the intended space and check safety straps where required.   **Stationary Racks**   Perform a visual inspection. Verify floor mounting hardware and check safety straps where required.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes

Sample Wireless Reference Verification Items

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	WL-100
Verification Item	Wireless Audio Systems Operation	**Date of Verification**	
Verifier		**Version**	
Functional Category	Wireless		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		
Description			
Verify that the operation of wireless audio systems (RF and IR) is as defined in the project documentation.			
Inputs			

This item should verify that the following is provided:
- All audio devices defined in the project documentation are either natively compatible (through built-in support) or are paired with an appropriate transmitter and/or receiver.
- All mobile devices (e.g., smartphones and tablets) are natively compatible or installed with compatible applications.
- All servers are either natively compatible (through built-in support) or are paired with an appropriate transmitter.
- All transmitters and receivers are installed and powered.
- Remote management is installed and configurable for all devices.
- All supporting wireless networks are in place and transmitter-receiver pairs are assigned with IP addresses.
- All software, authentication and security are in place for each device.

Tests, Procedures, and Equipment

Each system should be tested independently. Following independent system verification, all wireless audio systems should be operated simultaneously to check for interference.

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale

Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, it is recommended that a second level of testing is used to check:
- § Maximum output level
- § Total harmonic distortion + noise (THD+N)
- § Frequency response
- § Dynamic range (as defined by AES17: AES, *Standard method for digital audio engineering—Measurement of digital audio equipment*)
- § Crosstalk

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.

Metrics
N/A
Outputs
☐ Pass ☐ Fail
Notes

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InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	WL-101
Verification Item	Wireless Control Systems Operation	**Date of Verification**	
Verifier		**Version**	
Functional Category	Wireless		
Verification Phases	☐ Pre-Integration ☐ Systems Integration ☐ Post-Integration		

Description
Verify that the operation of wireless control systems (RF and IR) is as defined in the project documentation.

Inputs
This item should verify that the following is provided:

- Noise has been measured and factored.
- Bandwidth has been calculated and factored.
- Multiple systems can operate simultaneously.
- A channel scan has been performed to reveal which channels are available for use, noting the dynamic nature of this information.
- A review of gateway locations has been completed. Devices should not be near large metal objects, behind, under, or on top of metal objects, or any other place where interference could be an issue.
- All laptops are either natively compatible (through built-in support) or are paired with an appropriate transmitter.
- All mobile devices (e.g., smartphones and tablets) are natively compatible or installed with compatible applications.
- All transmitters and receivers are installed and powered.
- Receivers that are integrated with the corporate local area network to use the corporate wireless network have their internal wireless access points disabled.
- Remote management is installed and configurable for all devices.
- All supporting wireless networks are in place and transmitter-receiver pairs are assigned with IP addresses.
- All software, authentication and security are in place for each device.

Tests, Procedures, and Equipment
A site survey is highly recommended before systems are deployed to identify the channels available for use, interference, and signal propagation in relation to the space that will be covered by a specified number of transceivers. If any issues are detected, they should be brought up with the owner and the consultant so they could be immediate rectified.
Each system should be tested independently. Following an independent system verification, all wireless controls systems should be run simultaneously to check for interference. Typically, built-in tools provide signal strength and assist with the diagnosis of noise.
If issues are detected, a second level of testing using a spectrum analyzer is recommended.
Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.
Check that all control signals are being received and all commands executed reliably with no intermittent control dropouts.

Metrics
N/A

Outputs
☐ Pass ☐ Fail

Notes
Note the configuration.

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #	WL-102
Verification Item	Wireless Coordination	**Date of Verification**	
Verifier		**Version**	
Functional Category	Wireless		
Verification Phases	☐ Pre-Integration ☐ System Integration ☐ Post-Integration		
Description			
Verify that the environment is suitable for the required wireless services (RF and IR) to provide audio, video, and control, and can be implemented for the required number of channels as defined in the project documentation.			
Inputs			
Wireless microphones, wireless intercom, wireless IFB (Interruptible Fold-Back) or wireless personal monitoring systems require frequency coordination.			
Tests, Procedures, and Equipment			
A spectrum analyzer capable of measuring the higher bandwidths required for computer displays can be expensive, so this type of test equipment is often rented to perform measurements for a specific project. Spectrum analyzers are also a good tool to sweep RF to calculate bandwidth for a cable system or to sweep airborne RF to determine the available frequency bands for a wireless system.			
Metrics			
N/A			
Outputs			
☐ Pass ☐ Fail			
Notes			

InfoComm 10-2013 Verification Test Sheet

Project Name		Verification Item #		WL-103
Verification Item	Wireless Video Systems Operation	**Date of Verification**		
Verifier		**Version**		
Functional Category	Wireless			
Verification Phases	☐ Pre-Integration ☐ Systems-Integration ☐ Post-Integration			

Description
Verify that the operation of wireless video systems (RF and IR) is as defined in the project documentation.

Inputs
This item should verify that the following is provided:

- All display devices/projectors defined in the project documentation are either natively compatible (through built-in support) or are paired with an appropriate receiver.
- All laptops are either natively compatible (through built-in support) or are paired with an appropriate transmitter.
- All mobile devices (e.g., smartphones and tablets) are natively compatible or installed with compatible applications.
- All servers are either natively compatible (through built-in support) or are paired with an appropriate transmitter.
- All transmitters and receivers are installed and powered.
- Receivers that are integrated with the corporate local area network to use the corporate wireless network have their internal wireless access point disabled.
- Remote management is installed and configurable for all devices.
- Guest access USB dongles are located within the rooms for users.
- All supporting wireless networks are in place, and transmitter-receiver pairs are assigned with IP addresses.
- All software, authentication, and security are in place for each device.

Tests, Procedures, and Equipment

Each system should be tested independently. Following independent system verification, all wireless video systems should be operated simultaneously to check for interference.

Subjective testing should document any impairment in audio, video, or control responsiveness, frame drop, and audio dropouts that manifests below grade 4 on the five-grade impairment scale from ITU-R BT.500-13 (01/2012), as follows:

5 Grade Scale

Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

If issues are detected, a second level of testing using a spectrum analyzer is recommended.

Testing should be conducted over a seven-day, 24-hour period to pick up intermittent interference issues and during times all systems are running.

Metrics
N/A

Outputs
☐ Pass ☐ Fail.

Notes

Appendix C: Functional-Based Testing

The Standard defines a base list of verification items that are to be checked across each of the delivery phases of the project. While these items are considered to be comprehensive, the list should be tailored to suit the project, which may include removal of items and inclusion of new ones on an as-needed basis.

Once defined, the project-specific items can be used in a number of ways. One of these ways is as an input into functional-based testing.

Functional-based testing is a high-level set of tests based on the functionality the owner and their key stakeholders have requested and that the AV designer has required to be delivered in the project documentation.

Table 10 provides a sample of a functional-based test for videoconferencing, which is as represented on the graphical touchpanel.

Table 10 A sample videoconference functional testing form

Functionality Test	Pass	Fail	Comment
Video Conf Mode			
Network Connection			
0-9 Button			
* - #			
Microphone Mute			
Dial			
Hang Up			
Answer			
Speaker/Microphone Mute			
Speaker Volume			
Inbound Call			
Outbound Call			
Voice Intelligibility			
Video Quality/Connection Speed			
Content Sharing			
Remote Camera Control(s)			
Auto Camera Tracking Operation			

Functional-based testing is a very suitable testing methodology because it verifies against the defined user requirements and tests the functionality that is delivered.

Functional testing and the Standard can be used together as a powerful and comprehensive combination. It is recommended that functional testing is used as an overlay as part of the

post-integration phase. Functional-based testing would be performed to verify that the complete system works as it is intended and as the owner has directed.

Without verifying the system through the Standard's verification items prior to functional testing, some aspects of the system and associated environment are likely to be missed and won't be correctable if discovered at this later stage.

Appendix D: Performance Expectation Review

The Standard's Section 6.2: Selection Process Implementation defines a process whereby metrics should be selected and then modified based on achievable and realistic outcomes in which the intended building design, equipment, and owner priorities intersect (see figure 13).

Figure 13 Verification metric selection factors

Ideally, this should be a designer-led process. However, the installing contractor should verify that this process has been completed. The installing contractor should liaise with the project team prior to engaging with the client.

The assumptions made during the design process to determine performance expectations in some instances cannot be met due to changes in the building design, unexpected existing conditions, budget, project scope, and client objectives.

In some instances, the achievable metrics are not suitable for an intended application. Rather than having the designer or installer accept that a trade-off will occur and waiting for the outcome of the owner's feedback about the first use of the new installation, it is considered appropriate to provide advance notice to the owner to enable them to consider these issues and possible alternatives.

This process leads to better communication, which leads to better outcomes. When put clearly and without prejudice, most owners will seek to rectify any issues once suitable options are put for review.

All stakeholders in the process are looking to the AV designer and installer for leadership across all of the 13 functional areas defined in the Standard. It is no longer considered suitable for an AV provider to look after their own scope—best practice mandates that an AV provider direct the scope of work by all parties for a facility to truly deliver on its intended applications.

The following is a working example of how this issue may be addressed in writing to a client/owner.

Project X—Audiovisual Performance Assessment (New Building/New Fit-Out)

Client X,

In relation to Project X, we have reviewed the following and note where the intended performance will not meet the goals of the project:

- Owner's interview—Budget of $1.5M for videoconferencing room, client floor, boardroom and training facilities.
- Building design X—Interview with building services engineers/acoustic consultant

The following is noted against ANSI/INFOCOMM 10:2014, *Audiovisual Systems Performance Verification*:

Room X.YY—Videoconferencing Room

AP-112 Acoustical Ambient Noise—The mechanical cooling system in the room will not be able to provide a low-noise environment, which will affect the sound quality in the room.

It is considered that two options are available for corrective actions, as follows:

- Option 1: Mechanical system redesigned in favor of a low noise low velocity system with units mounted outside the room.
- Option 2: Due to the noise output of the mechanical system, the intended design using ceiling-mounted microphones will pick up more noise than people's voices and will not be a suitable solution. It is recommended that gooseneck microphones are mounted to the table one for every two seated positions.

General Client Floor

PHYSE-103 Vibration—The client floor is located on the top floor of the building, just below the main rooftop plant room. All rooftop plant and equipment are due to be mounted on vibration pads. It is considered that this will not reduce vibration to the level required by the AV systems design. It is recommended that all rooftop plant is mounted on springs to avoid excessive

structure-borne noise, which is considered very difficult to correct once in operation. It is considered that the ceiling-mounted document cameras and rear projection screen will exhibit vibration in their displayed images.

Two options are available for corrective actions, as follows:

- Option 1—Rooftop equipment mounted to springs in accordance with specialist acoustical consultant advice.

- Option 2—Move the client floor from the top level of the building to a floor that is not directly impacted. Specialist acoustical and vibration analysis is considered required to enable assessment.

Main Boardroom

AP-105 AV Room Reverberation Time—The finishes of the boardroom with one wall glass and stone on the other with no acoustic treatment creates a possibility for flutter echo as well as a reverberation time that is not suitable for audio- and videoconferencing applications.

It is considered that two options are available for corrective actions, as follows:

- Option 1—Remove audio- and videoconferencing from this room and use the adjacent telepresence suite for these applications.

- Option 2—Provide acoustic treatment to bring the reverberation time down to the target value of 0.6 to 0.8 s.

Recommendation: We recommend proceeding with option 2 based on our understanding of the needs of the boardroom.

We have raised these issues because they would negatively affect the AV system performance. We also note that the following applications are not considered to work to your expectations unless a change is made to the building design or AV requirements:

- Boardroom—Audio- and videoconferencing will be affected.

- Videoconferencing room—Change mechanical system or use gooseneck/tabletop microphones.

- Client floor—All rooms with document cameras will not have image stability.

We look forward to working with you on these issues.

Regards,

Appendix E: Using the Standard as an Assessment Tool

The Standard can also be used at any stage of a project, not just as defined in the Standard.

It can be used in the following ways and phases:

- In the design stage, to create design criteria and documentation requirements
- As an assessment tool to rate existing conditions
- To recommission existing systems

The reference verification items within the Standard can be used as a powerful assessment tool to review existing room and system conditions and clearly define the needs of each application to the client to establish a baseline.

This creates a communication and collaboration pathway to increase the certainty of delivering higher quality AV systems.

On the following page is an example of how verification items can be used in a report to document existing conditions.

Project Y—Audiovisual Performance Assessment (Existing Building/Refresh)

Client Y,

In relation to Project Y, we have reviewed the existing rooms that are to have installed and/or upgraded AV systems and note where the assessed existing conditions will not meet the intended goals of the project.

Existing Building Y

- AP-105 Reverberation Time—Our test results provided a result of 1.2 s. This is not ideal and will result in reduced clarity of the audio system. We recommended increasing the acoustic treatment in the room.
- AP-112 Acoustical Ambient Noise—68 dB(A). The existing HVAC system noise in room Y.XX is not considered suitable for videoconferencing. We reviewed the adjacent room and the background noise is 48 dB(A), which would be better suited.
- PHYSE 102 Lighting—The existing halogen down-lighting is not considered suitable. We would be happy to arrange for replacement as part of our works.

It is recommended that a small works package be used to upgrade these items and enable the best performance of the AV system.

We look forward to working through with you on these issues.

Regards,

Appendix F: Sample Completed
Verification List

The following testing sheet example is based on a sampling of the InfoComm International, Audiovisual Systems Performance Verification Checklist.
http://www.infocomm.org/cps/rde/xbcr/infocomm/CAVSP_Checklist.pdf

The verification checklist is based on InfoComm 10:2013, *Audiovisual Systems Performance Verification*.

Verification Items are applicable to support pre-integration, integration, post-integration, and closeout/substantial/practical completion activities.

This testing sheet example is of a consultant acceptance test, as part of substantial/practical completion verification. This test assumes that the AV contractor has fulfilled their obligation to ensure that the systems are tested, complete and free of operational defects. Verification Items within this list are verified by visual and or audible methods as part of normal room use case operational scenarios.

The sample test section below was created with a software application called iAuditor that allows for efficient documentation of verification items and statuses.

iAuditor allows inserting photos into the report to substantiate the passing or failing of a particular test.

The response column indicates if a particular test has passed/failed or is not applicable to the space. The details column instructs the contractor what tests or specific functional items need to be addressed.

iAuditor Test Example

Question	Response	Details
Audio Performance		
Verification items within this category verify the audio system's performance, stability, and conformance to requirements provided within project documentation. Project-specific verification items that address capture, transformation, or reproduction of program audio or voice; audio signal management; acoustic environment; and loudspeaker operations shall be listed in this section.		
AP-100 – Emergency Muting	No	Not working, no fire alarm cable / interface installed.
Verify that any required muting or operational change of the installed sound system(s) has been made in accordance with local regulations in the event of a life safety or similar emergency.		
AP-101 – Loudspeaker Zoning	Yes	
Verify that loudspeaker zones are wired as defined in the project documentation.		
AP-102 – Alignment of Multiple Audio Source Levels	Yes	
Verify calibration of permanent audio system inputs such that the difference between any input signal level after the first common gain adjustment meets the requirements of the project documentation. This verification item should require a metric to be verified.		
AP-103 – Audio Buzz and Rattles	Yes	
Verify that no audible noise caused by improper installation of any equipment provided in completed system(s) is present.		
AP-104 – Audio Routes	Yes	
Verify that all audio routes are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and routing as defined in the project documentation.		
AP-105 – AV Room Reverberation Time	Yes	
Verify reverberation time meets the requirement defined in the project documentation. This verification item shall require a metric to be verified.		
AP-106 – DSP Programming	Yes	
Verify that all DSP-based products have been programmed as defined in the project documentation.		
AP-107 – Loudspeaker Physical Alignment	N/A	
Verify that loudspeakers are placed and aimed as defined in the project documentation.		
AP-108 – Loudspeaker Polarity	Yes	
Verify that all loudspeakers have correct polarity as defined in the project documentation.		
AP-109 – Loudspeaker Time Alignment	N/A	
Verify that loudspeaker time alignment performs as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-110 – Phantom Power	Yes	
Verify that phantom power is provided at the correct voltage and correct locations as defined in the project documentation.		
AP-111 – Loudspeaker Transformer Tap Setting	Yes	
Verify the loudspeaker transformer tap setting in constant voltage systems is as defined in the project documentation.		
AP-112 – Acoustical Ambient Noise	No	HVAC noise, balancing issue?
Verify that the background acoustic noise levels within audiovisual spaces are within the required limits as detailed in the project documentation. This test is specifically related to ambient noise levels and not audio system quiescent noise, which is tested separately. This verification item shall require a metric to be verified.		
AP-113 – Assistive Listening Devices	Yes	
Verify that all devices that are part of the assistive listening system have been tested as a complete end-to-end personal listening system. Verify that the assistive listening system complies with regulatory requirements and adheres to project documentation. This verification item should require a metric to be verified.		
AP-114 – Audio Coverage in Listener Areas	Yes	
Verify that coverage of the audio systems in listener areas meets the performance requirements as defined in the project documentation. ANSI/INFOCOMM 1M-2009, Audio Coverage Uniformity in Enclosed Listener Areas should be used. Perform separate tests for all independent systems within the project, including but not limited to program sound, speech reinforcement, and show relay. This verification item should require a metric to be verified.		
AP-115 – Audio Dynamics	Yes	
Verify use of audio dynamics, including but not limited to noise compensation, automatic gain control, gating, feedback suppression, compression, limiting, delays, and levelers meets the requirements defined in the project documentation.		
AP-116 – Audio Level Exceeds Background	Yes	

Noise Level		
Verify that the audio level provided by the installed audio system exceeds the background noise level as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-117 – System Electronic Frequency Response	Yes	
Verify that the electronic frequency response of the audio system is as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-118 – Audio System Equalization for Spectral Balance	Yes	
Verify that the audio system equalization is in accordance with the acoustic response curves as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-119 – Audio System Latency	Yes	
Verify that audio system latency meets requirements defined in the project documentation. This verification item shall require a metric to be verified.		
AP-120 – Audio System Speech Reproduction at Listener Positions	Yes	
Verify that the audio system provides speech reproduction (intelligibility) as defined in the project documentation. This verification item should require a metric to be verified.		
AP-121 – Audio System Total Harmonic Distortion	Yes	
Verify that the total harmonic distortion of the installed audio system is as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-122 – Conferencing Audio Levels	No	Inbound levels need adjustment
Verify that in a conferencing audio application, the incoming and outgoing audio levels are checked and adjusted in the system as defined in the project documentation. This verification item should require a metric to be verified.		
AP-123 – Conferencing Echo Suppression Performance	Yes	
Verify that a system with conferencing capability performs at nominal operating levels in a full duplex mode with echo and latency performance as defined in the project documentation.		
AP-124 – Loudspeaker Impedance	Yes	
Verify that all loudspeaker circuits have the correct impedance as defined in the project documentation. This verification item should require a metric to be verified.		
AP-125 – Microphone Physical Alignment and Placement	Yes	
Verify proper alignment and placement of microphones in the system as defined in the project documentation.		
AP-126 – Microphone Gain Before Feedback	Yes	
Verify that the speech reinforcement system is operating without feedback and at audio levels as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-127 – Microphone Level Alignment	Yes	
Verify calibration of microphone inputs so that the difference between any input signal level after the first common gain adjustment meets the requirements of the project documentation. This verification item should require a metric to be verified.		
AP-128 – Multi-channel Loudspeaker System Output	N/A	
Verify that the audio outputs of a multi-channel loudspeaker system are assigned correctly to designated outputs as defined in the project documentation.		
AP-129 – Sound Masking	N/A	
Verify that audio system sound-pressure levels and equalization are adjusted to the level of sound masking as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-130 – Audio Reinforcement System Headroom	Yes	
Verify that the audio system is capable of performing above nominal operating levels without distortion as defined in the project documentation. This verification item shall require a metric to be verified.		
AP-131 – Audio System Signal-to-Noise Ratio	Yes	
Verify audio system electrical signal-to-noise ratio meets the minimum levels defined in the project documentation. This verification item should require a metric to be verified.		

Video Performance

Verification items within this category verify the video system's performance, stability, and conformance to requirements provided within project documentation. Project-specific verification items that address capture, transformation, or reproduction of video; video signal management; and camera operations shall be listed in this section.

VP-100 – EDID Management Plan	Yes	
Verify that the EDID (Extended Display Identification Data) management plan has been implemented as defined in the project documentation.		
VP-101 – HDCP Management Plan	Yes	
Verify that the HDCP (High-bandwidth Digital Content Protection) management plan has been implemented as defined in the project documentation.		
VP-102 – Projected Display Physical Alignment	No	Alignment issues, not square with screen producing keystone image
Verify that the combined installation of projector and screen provides a displayed image that is correctly aligned to the active projection screen surface without misalignment unless an alternative condition is specified in the project documentation.		
VP-103 – Video System Pixel Failure Tolerance	Yes	
Verify that all displayed images do not have pixel failures (bright or dead pixels) that exceed the requirements of the project documentation or the manufacturer's specifications. This verification item shall require a metric to be verified.		
VP-104 – Image Geometry	No	Keystone issues
Verify that all displayed images are correctly focused, have the correct image geometry and are free from distortion (e.g., stretching, keystone, barrel/pincushion). Any requirements for projection mapping or image shaping to unusual surfaces should be validated in accordance with the requirements of the project documentation.		
VP-105 – Displayed Image Performance	Yes	
Verify that the components of the displayed image system(s) (projection or direct-view) perform(s) as required with relation to image size, viewing angles, sight lines, viewer locations and/or any other requirements as defined in the project documentation.		
VP-106 – Colorimetry	Yes	
Verify calibration of all video displays to ensure they display colors uniformly to a common reference standard as defined in the project documentation.		
VP-107 – Multiple Resolution Performance of Video Displays	Yes	
Verify that the system(s) accurately displays all resolutions required by project documentation on all displays within the system (i.e., no pixel shift, no geometric distortion, no artifacts from scaling, letterboxing, pillar boxing, or window boxing).		
VP-108 – Projected Display Brightness Uniformity	Yes	
Verify that the combined installation of projector and screen provides a display to the viewer that meets the requirements of the project documentation. This verification item shall require a metric to be verified.		
VP-109 – Projected Image Contrast Ratio	Yes	
Verify that the system conforms to the appropriate viewing category as defined in the project documentation. The testing methodology in ANSI/INFOCOMM 3M- 2011 shall be used. The projected image contrast ratio shall be measured for all projected images within the system. This verification item shall require a metric to be verified.		
VP-110 – Test Video Routes	Yes	
Verify that all video routes are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and routing required by the project documentation.		
VP-111 – Video Camera Image and Operation	Yes	
Verify that cameras, lenses, and pan/tilt systems operate as defined in the project documentation. Inspect the camera image through the full lens operation		

Audio/Video Performance

Verification items within this category verify linked audio and video system elements that cannot be separated due to their functional requirements. These items verify performance, stability, and conformance to requirements provided within project documentation. Project specific verification items that address linked audio and video system elements shall be listed in this section.		
AVP-100 – Emergency Communications	Yes	
Verify that emergency communications systems properly receive inputs and information from other systems (including but not limited to life safety systems, security systems, and weather notifications), deliver appropriate notifications to target audiences, comply with regulatory requirements, and adhere to requirements defined in the project documentation.		
AVP-101 – Genlocking (Video Synchronization)	N/A	
Verify that the video synchronization of the system is performing as defined in the project documentation.		

AVP-102 – Audio and Video Recording	N/A	
Verify that audio and video signals are being routed to the recording device(s) and that the recording device(s) is operating correctly, as defined in the project documentation.		
AVP-103 – Audio/Video Sync	N/A	
Verify that audio/video synchronization is maintained to ensure the proper time alignment of signals during playback at the point of user experience or transmission as defined in the project documentation. This verification item should require a metric to be verified.		
AVP-104 – Radio Frequency Television Distribution	N/A	
Verify that the radio frequency and satellite intermediate frequency distribution systems provide all services to all endpoints as defined in the project documentation. This verification item shall require a metric to be verified.		
AVP-105 – Source Testing	Yes	
Verify that the signal produced by a source typical of what will be used in normal operation of the system is routed through the system to applicable endpoints and produces the performance as defined in the project documentation. A test generator shall not be used for this verification item.		

Cable Management, Termination, and Labeling

Verification items within this category verify the workmanship for installation and management of all systems' cabling, labels, and connections conformance to requirements provided within project documentation. Project-specific verification items that address site cabling, rack cabling, furniture cabling, and loose cables shall be listed in this section. In this context, "cable" refers to all cabling including fiber and copper (e.g., twisted pair, multicore, coaxial).		
CABL-100 – Cable Bend Radius	Yes	
Verify that cables are not bent beyond their minimum bend radius as specified in cable data sheet in order to maintain signal integrity as defined in the project documentation. Project documentation may state a larger radius to allow for a safety margin.		
CABL-101 – AV Connector Plate Input and Output Labeling	Yes	
Verify that all AV connector plate inputs and outputs are labeled as defined in the project documentation.		
CABL-102 – AV Connector Seating	Yes	
Verify that all AV connectors are correctly keyed, seated, and latched to respective connection points as defined in the project documentation. Conditions where physical parameters exceed the connector's ability to maintain full seating should be resolved as defined in the project documentation.		
CABL-103 – AV Connector Verification	Yes	
Verify that all AV cable terminations are made securely and meet the recommendations of the connector and cable manufacturer(s), published standards, and requirements defined in the project documentation.		
CABL-104 – AV Equipment Power Cable Management	Yes	
Verify that all AV equipment power cables are managed as defined in the project documentation. Verify that cables are managed in a uniform and acceptable manner so as not to compromise safety/OEM warranty, AV signal quality, and/or future field service.		
CABL-105 – AV System Cable Labeling	Yes	
Verify that all AV system cables are identified by a unique ID as defined in the project documentation. Verify that this unique ID is displayed permanently at both ends of the cable, is legible, and is positioned where it can be seen without undue disturbance.		
CABL-106 – Cable Separation	Yes	
Verify that both site and rack cables have appropriate separation according to signal type and level as defined in the project documentation.		
CABL-107 – Cable Supports	No	Cables not tied up within the ceiling near rack.
Verify that all cables are supported throughout their lengths as defined in the project documentation.		
CABL-108 – Cable Ties	Yes	
Verify that, where appropriate, cable ties are used to secure the cables, are correctly tensioned, and that the correct type of cable tie(s) is used as defined in the project documentation.		
CABL-109 – Cables Bundled by Type	No	All cables bundled together from ceiling to top of rack.
Verify that cables are only bundled together when their construction, signal type, and signal level are compatible and will not cause measureable crosstalk or interference between cables.		
CABL-110 – Cables Dressed	Yes	
Verify that cables are dressed to ensure that all rack and site cables are installed to provide serviceability, safety, and		

aesthetics as defined in the project documentation.		
CABL-111 – Patch Panel Configuration	N/A	
Verify that all patch panels have been correctly wired and configured as defined in the project documentation.		
CABL-112 – Patch Panel Labeling	N/A	
Verify that all patch panels have been labeled as defined in the project documentation. Verify that all labeling is machine-printed, consistent, durable, accurate, and legible.		
CABL-113 – Termination Stress	Yes	
Verify that all cable terminations have been completed and adequately supported to minimize stress on the termination point and/or connector.		
CABL-114 – AV Connector Plate Consistent Labeling	Yes	
Verify that AV connector plates have consistent labeling throughout the project as defined in the project documentation.		
CABL-115 – AV System Cabling Verification	Yes	
Verify that all cabling is the correct type and routed correctly from point to point as defined in the project documentation.		
CABL-116 – Cable Length Required for Serviceability	Yes	
Verify that sufficient cabling is available so the device can be placed in a serviceable location as defined in the project documentation.		

Control Performance

Verification items within this category verify the control system's performance, usability, stability, and conformance to requirements provided within project documentation. Project specific verification items that address system communications, interface and control devices, mobile device integration, external system integration (e.g., life safety, security, environmental), automated system functions, and user interface operations shall be listed in this section.		
CON-100 – Control System Communications	Yes	
Verify that all control communications are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and functionality as defined in the project documentation.		
CON-101 – Interfacing and Control of External Devices and Systems	Yes	
Verify that AV control system interfaces to and from control systems provided by others conform to requirements as defined in the project documentation.		
CON-102 – Mobile Device Integration	N/A	
Verify that mobile devices that are to be supported are integrated and operating as defined in the project documentation.		
CON-103 – System Response to Emergency Condition(s)	Yes	
Verify that any required response of the installed audiovisual system(s) in the event of a life safety or similar emergency operates in accordance with local regulations and as defined in the project documentation. This item specifically excludes sound system response to an emergency condition, which is covered under item AP-100 Emergency Muting.		
CON-104 – Control System Automated Functions	Yes	
Verify that all time-dependent or automated functions executed by the control system conform to requirements as defined in project documentation.		
CON-105 – Control System User Interface Performance	Yes	
Verify that the control system is implemented in a manner consistent with the requirements as defined in the project documentation.		
CON-106 – Control System Response Time	Yes	
Verify that the control system provides the user response time and maximum latency defined in the project documentation. This verification item should require a metric to be verified.		

System and Record Documentation

Verification items within this category verify that the system's project-specific record documentation has been completed. Any documentation should be delivered in electronic format wherever possible and practical. Project-specific verification items that address drawings and specifications, test reports, manuals, and acceptance reports shall be listed in this section.

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DOC-100 – Final Inventory of AV Equipment	Yes	
Verify that all equipment has been delivered as defined in the project documentation.		
DOC-101 – Approval of Samples	Yes	
Verify that samples of all equipment to be used as defined in the project documentation have been submitted for approval.		
DOC-102 – Delivered Product Against Samples	Yes	
Where samples of products have been required for approval, verify that the products that are delivered are the same and of the same quality.		
DOC-103 – Wireless Frequency Licensing	N/A	
Verify that the correct and valid wireless frequency licensing permits have been obtained for legal operation of the system.		
DOC-104 – Consultant's Testing	No	Room did not pass
Verify that any consultant's testing requirements defined in the project documentation have been performed and approved.		
DOC-105 – General Contractor's Testing	Yes	
Verify that any general contractor's testing requirements defined in the project documentation have been performed and approved.		
DOC-106 – Integrator's Testing	Yes	
Verify that any integrator's testing requirements have been performed and approved as defined in the project documentation.		
DOC-107 – Manufacturer's Testing	N/A	
Verify that any manufacturer's testing requirements defined in the project documentation have been performed and approved.		
DOC-108 – Owner's Testing	Yes	
Verify that any owner's testing requirements defined in the project documentation have been performed and approved.		
DOC-109 – Third-Party Testing	N/A	
Verify that any third-party testing requirements have been performed and approved as defined in the project documentation.		
DOC-110 – Substantial/Practical Completion	Yes	
Verify that a conditional acceptance of the project has been issued by the owner or owner's representative, acknowledging that the project or a designated portion is substantially/practically complete and ready for use by the owner, however some requirements and/or deliverables defined in the project documentation may not be complete.		
DOC-111 – As-Built Drawings Complete	No	Drawings in process
Verify that a complete set of accurate as-built drawings indicating all AV devices, AV device locations, mounting details, system wiring and cabling interconnects, and all other details has been provided as defined in the project documentation.		
DOC-112 – Audio System Test Reporting	**Yes**	
Verify that the audio system test report has been completed and issued as defined in the project documentation.		
DOC-113 – Control System Test Reporting	Yes	
Verify that the control system test report has been completed and issued as defined in the project documentation.		
DOC-114 – Final Commissioning Report and System Turnover	No	Report to be issued
Verify that the final commissioning report has been completed, issued to the proper entity, and accepted as defined in the project documentation.		
DOC-115 – Required Closeout Documentation	No	Documents in process
Verify that a complete set of as-built system documentation has been provided as defined in the project documentation.		
DOC-116 – Software Licensing	Yes	
Verify that the usage and ownership rights have been assigned as defined in the project documentation.		
DOC-117 – User Manuals	No	Documentation in process, draft version at test.
Verify that manufacturer's user manuals are delivered to the owner in a format defined in the project documentation (e.g., binders, PDFs), or dispose of the manuals in a responsible manner (recycling) if the owner specifies that they do not wish to receive the manuals. Integrator- or programmer-created manuals and documentation shall be delivered to the owner in a format defined in the project documentation.		
DOC-118 – Video System Test Reporting	Yes	
Verify that the video system test report has been completed and issued as defined in the project documentation.		
DOC-119 – Warranties	Yes	
Verify that all warranties are activated and that all warranty details have been passed to the owner as defined in the project documentation.		
DOC-120 – Final Acceptance	Yes	
Verify that a final acceptance of the project has been issued by the owner or owner's representative, acknowledging that the project is 100% complete, that all required deliverables, services, project-specific verification lists, testing, verification and signoffs have been received, and that all requirements defined in the project documentation have been satisfied and completed.		

Electrical

Verification items within this category verify the system's interaction with mains voltage distribution and DC power distribution within the system are in conformance with the regulatory authority and project documentation. Project-specific verification items that address power distribution, monitoring, and sequencing shall be listed in this section. This category specifically excludes testing of the building's fixed electrical installation, which is deemed the responsibility of others as defined in the project documentation or by regulatory authority.

ELEC-100 – AV Equipment Connected to Proper Circuit	Yes	

Verify that all AV equipment is powered from the designated power circuit and outlet as defined in the project documentation. No additional (non-AV) equipment should be connected unless permitted in the project documentation.

ELEC-101 – Grounding/Earthing	Yes	

Verify that all elements of the AV system are correctly bonded to an electrical ground/earth in accordance with the requirements of the regulatory authority and as defined in the project documentation.

ELEC-102 – Mains Voltage Sub-Distribution Integrity	Yes	

Verify that all electrical sub-distribution systems provided by the AV contractor in equipment racks, furniture, and similar structures meet local regulatory requirements for electrical integrity.

ELEC-103 – Power Sources	Yes	

Verify that the sources of mains voltage AC power to be used for the supply of AV equipment are correct as defined in the project documentation and have been tested to the outlet in accordance with local electrical standards.

ELEC-104 – Power Sequencing	Yes	

Verify that the power sequencing of devices is correct as defined in the project documentation.

ELEC-105 – UPS Operation	Yes	

Verify that the uninterruptible power supply (UPS) is performing to the specifications as defined in the project documentation.

ELEC-106 – DC Power Distribution	Yes	

Verify that all DC powered devices are receiving the proper voltage and current for normal operation.

ELEC-107 – Power Loss Recovery	Yes	

Verify that the AV systems resume normal operation on the restoration of power following a hard electrical power outage. Power loss recovery shall include verification of the resumption state on power recovery. Resumption state shall be the control system start-up condition/start page (where applicable) and resetting all devices to a known state as defined in the project documentation.

ELEC-108 – Power Monitoring	Yes	

Verify power-monitoring equipment is working and reporting as defined in the project documentation. Power-monitoring equipment should be verified with a known electrical load where possible. If power-monitoring data is being collected for an energy management system, connectivity with the system should be verified.

Information Technology

Verification items within this category verify the Information Technology elements of the system perform, provide stability, and conform to requirements provided within project documentation. Project-specific verification items that address network integration and performance, IT systems integration, IT security, unified communications, and software licensing shall be listed in this section. This category specifically excludes testing of the owner's information technology systems unless specified in the project documentation.

IT-100 – Content Delivery Network	N/A	

Verify that the content delivery network (e.g., digital signage) is in place and provides the required connectivity for the required audio, video, and control systems. Verify that all required content licensing has been acquired.

IT-101 – IEEE 802 Wireless Security	Yes	

Verify that the wireless network is protected in accordance with the client/owner's information security policies from unauthorized access and provides the required connectivity for the audio, video, and control systems.

IT-102 – Network Bandwidth	Yes	

Verify that the required network bandwidth is available for control, audio, video, and data as part of either a shared or a dedicated audiovisual network.

IT-103 – Network QoS (Quality of Service)	Yes	

Verify that the required Quality of Service (QoS) is in place for audio, video, and data as part of either a shared network or a dedicated audiovisual network.

IT-104 – Network Security	Yes	

Verify that the shared or dedicated network is secure as defined in the project documentation and accessible to suit the required audio, video, and control systems.

IT-105 – Telephony	Yes	

Verify that any required telephony connections to the AV system are in place and connectivity is verified.

IT-106 – Unified Communications	Yes	
Verify that any connections to IT-based unified communication applications that will interface with the AV system have been planned for and integrated.		
IT-107 – AV IP Address Scheme	Yes	
Verify and document that all network-connected equipment has the correct IP address, subnet mask, hostname, and gateway configuration as defined in the project documentation.		
IT-108 – IEEE 802 Wireless Networks	Yes	
Verify that the wireless network configuration is correct and valid (e.g., channel no., SSID, TX power) in defined areas of use as defined in the project documentation. Verify that there is adequate channel separation between any client wireless networks that are required to co-exist in the same area.		
IT-109 – PoE (Power over Ethernet)	Yes	
Verify that PoE (Power over Ethernet) devices are supplied with correct power required for normal device operation. Verify under normal operations that the switch providing PoE has the capacity to power all of the devices that are connected to it.		
IT-110 – Network Topology	Yes	
Verify that the network for audio, video, and control is of a suitable topology to support the services to be delivered as defined in the project documentation.		
IT-111 – Application Integration	Yes	
Verify that the audiovisual and control systems have been integrated and have been fully configured with headend software, including monitoring and asset management; databases; web-based front ends; digital signage software and systems; content generation and distribution platforms; and appliances as defined in the project documentation.		
IT-112 – Enterprise Management Tools	Yes	
Verify that enterprise management tools such as central monitoring client/server or web-based applications have been installed and connected to all systems they are required to monitor or control as specified in the project documentation.		
IT-113 – Identity Management	Yes	
Verify that all systems-authentication credentials are configured correctly. Any temporary credential used during system installation and commissioning should be removed. User and group authentication and authorization are verified based on the requirements from the project documentation. Connectivity with the central directory, database, or other identity authority should be verified.		
IT-114 – Network Performance Under Full Functional Load	Yes	
Verify that the network can provide the required operational performance to carry control, audio, video, and data under production load and at times of peak production load (refer to IT-102 Network Bandwidth).		
IT-115 – Remote Access	Yes	
Verify that remote access to AV and IT systems are configured as defined in the project documentation.		
IT-116 – Remote Management	Yes	
Verify that remote management tools such as virtual touchpanels, internal web applications, or manufacturer's applications are configured and functional as required by the project documentation and/or manufacturer's specification.		

Operations and Support

Verification items within this category verify that operational planning and handover of elements of the system have been conducted and conform to requirements provided within project documentation. Project-specific verification items that support planning for operations or address handover elements shall be listed in this section.		
OP-100 – Software	Yes	
Verify that all control programming code, DSP configuration files, and any other associated software have been provided as defined in the project documentation.		
OP-101 – Battery Management Plan	Yes	
Verify that a battery management plan has been completed and supplied to the owner in the project documentation package.		
OP-102 – Content Management Plan	Yes	
Verify there is a plan for managing the content to be delivered by the audiovisual systems, including the means to create content and update content when new information needs to be conveyed.		
OP-103 – System Content Provided	Yes	
Verify that any owner, vendor, or third-party-produced system content that is required for operations as defined in the project documentation has been supplied, loaded, and tested in the completed AV system.		

Physical Environment

Verification items within this category verify that built elements that interact with a system perform and conform to requirements provided within project documentation. Project specific verification items that address structural reinforcement, lighting, enclosures, finishes, and other built elements shall be listed in this section.		
PHYSE-100 – Divisible Spaces	N/A	

Verify that the divisible spaces provide the functionality defined in the project documentation.		
PHYSE-101 – Human Factors, Usability, and Ergonomics	Yes	
Verify that ergonomics and usability elements for audience and system users are installed and configured as defined in the project documentation.		
PHYSE-102 – Lighting	Yes	
Verify that the lighting systems are suitable for each type of application (e.g., video conferencing, presentation, broadcast, performance) as defined in the project documentation. This verification item should require a metric to be verified.		
PHYSE-103 – Vibration	Yes	
Verify that the physical environment is suitable for the intended audiovisual systems in relation to all sources of vibration affecting stability of equipment such as videoconferencing cameras, document cameras, and fixed screen and projector locations.		
PHYSE-104 – Backing/Blocking/Framing	Yes	
Verify that installed backing, blocking, and framing meets project documentation requirements and industry standards for installation means and methods.		
PHYSE-105 – Clean Building Handover	Yes	
Verify that the area is clean, free of dust, and suitable for equipment installation and that no further work is planned that will release contaminants into any AV equipment area. Verify that the area released is isolated from any areas not yet released.		
PHYSE-106 – Coordinated Construction Elements	No	Speakers have been displaced due to lighting element changes.
Verify that the elements (including but not limited to spatial requirements and building services) required by the AV system that are coordinated with other disciplines have been provided as defined in the project documentation.		
PHYSE-107 – Device Enclosures	Yes	
Verify that device enclosures accommodate the intended device and that all necessary environmental controls (e.g., heating, cooling, humidity) are incorporated into the enclosure as defined in the project documentation.		
PHYSE-108 – Finishes	Yes	
Verify AV equipment, furniture, fixtures, and accessories against the project documentation.		
PHYSE-109 – Floor Boxes/Wall Boxes/Ceiling Boxes	Yes	
Verify that installed floor, wall, and ceiling boxes meet project documentation and regulatory authority requirements.		
PHYSE-110 – HVAC Commissioned	No	HVAC noisy, not balanced or commissioned.
Verify the HVAC system has been tested and balanced prior to completing verification items AP-112 and AP-116.		
PHYSE-111 – HVAC Operations	Yes	
Verify the HVAC system has begun continuous operations in advance of equipment operations.		
PHYSE-112 – Structural Mounting	Yes	Projector mounting structure requires framing and securing, projector moves easily and does not stay aligned to screen.
Verify configuration and compatibility of structural accommodations and all mounting hardware based on the intended application. All equipment mounting hardware shall be installed in the manner specified by the hardware manufacturer.		
PHYSE-113 – Protection of Installed Equipment	Yes	
Verify that all elements of the AV system are free of damage.		
PHYSE-114 – Accessibility	Yes	
Verify that all systems are accessible in accordance with regulatory requirements.		

Physical Installation

Verification items within this category verify that the workmanship for installation of all the equipment within the system except cabling conforms to requirements provided within project documentation. Project-specific verification items that address containment, installation, security, and equipment cleanliness shall be listed in this section.		
PHYSI-100 – Cable Containment/Conduit	Yes	
Verify that installed containment/conduit capacity and routes meet project documentation requirements, industry standards, and regulatory requirements for installation means and methods. Verify that installed containment/conduit is serviceable and free of contaminants.		
PHYSI-101 – AV Rack Air Flow and Temperature Performance	Yes	
Verify that the AV rack(s) provides the air flow as required in the project documentation. Verify that the temperature in the AV		

rack has been measured and is within tolerances defined by manufacturers' guidelines and the project documentation. This verification item shall require a metric to be verified.		
PHYSI-102 – Equipment Security	Yes	
Verify that equipment is secured as defined in the project documentation. Verify that all security systems, devices, and manufacturer security accessories are installed and verified to be operating as defined in project documentation. Verify that keyed devices have been keyed as defined in the project documentation and devices requiring configuration have been configured as defined in the project documentation and are verified to be operating within specification.		
PHYSI-103 – AV Equipment Labeling	Yes	
Verify that all AV equipment has been labeled in accordance with the requirements of the project documentation. All labeling must be consistent, durable, accurate, and visible without dismantling of sub-assemblies.		
PHYSI-104 – Plumb and Level/Square	Yes	
Verify that all AV equipment has been installed, aligned, or angled correctly as defined in the project documentation. Level and plumb are the default requirement unless particular angles or other alignments are defined in the project documentation.		
PHYSI-105 – Site Security	Yes	
Verify that all elements of the AV system are free from loss, damage, or tampering.		
PHYSI-106 – AV Equipment Located Per Project Documentation	Yes	
Verify that AV equipment is installed at the location and/or in the rack or enclosure as defined in the project documentation. Equipment is installed per the elevation or other specification provided by the project documentation or the manufacturer's specification.		
PHYSI-107 – AV Rack Cleanliness	No	Rack needs cleaning, dirt, dust and constriction debris within room.
Verify that all components installed in AV equipment racks are free from dirt, dust, water, or any other element that would compromise the performance and/or longevity of the AV system.		
PHYSI-108 – Non-End-User Controls Protection	Yes	
Verify that installed items with user-facing controls that are not intended for end-user access have been covered, disabled, or otherwise secured to prevent end-user operation.		
PHYSI-109 – Optical Components Cleanliness	Yes	
Verify that all optical components, such as lenses and mirrors, are free from dirt, dust, damage, or markings that would compromise the optical performance of those system components.		
PHYSI-110 – Handling of Accessories Otherwise Undefined	Yes	
Verify that all items that are pre-packaged with primary system equipment but have no documented/planned use in the AV system(s) are managed in accordance with the project documentation.		
PHYSI-111 – Turnover of Accessory System Elements	Yes	
Verify that any equipment that may be considered portable and/or otherwise not specifically incorporated into the installed AV system(s) has been set up, configured, and tested.		

Serviceability

Verification items within this category verify that the system is serviceable in conformance with the requirements provided within project documentation. Project-specific verification items that address system accessibility, access panels, and rack clearance shall be listed in this section.		
SERV-100 – Access Panels	Yes	
Verify that any access panels that have been installed to provide access to any type of AV equipment are properly sized and positioned as detailed in the project documentation.		
SERV-101 – Ability to Maintain and Service Equipment	Yes	

Verify that all equipment is accessible and capable of being maintained, serviced, cleaned, or adjusted as necessary. Verify that all equipment requiring regular cleaning or maintenance is accessible without requirement for special equipment or tools that would disrupt the normal use of the facility and systems therein.		
SERV-102 – Input and Output Panel Accessibility	Yes	
Verify that all input and output panels are accessible and meet all requirements for user access and placement.		
SERV-103 – Rack Clearance	Yes	
Verify rack placement and use for physical stability in accordance with the project documentation and regulatory authority.		

Wireless

Verification items within this category verify that all aspects of wireless audio, video, and control systems perform and conform to the requirements provided within project documentation. Project-specific verification items that address radio frequency, infrared, Bluetooth®, Digital Enhanced Cordless Telephony (DECT), and proprietary wireless systems shall be listed in this section.		
WL-100 – Wireless Audio Systems Operation	Yes	
Verify that the operation of wireless audio systems (RF and IR) is as defined in the project documentation.		
WL-101 – Wireless Control Systems Operation	Yes	
Verify that the operation of wireless control systems (RF and IR) is as defined in the project documentation.		
WL-102 – Wireless Coordination	No	Wireless interference experienced, need to coordinate frequency selections.
Verify that the environment is suitable for the required wireless services (RF and IR) to provide audio, video, and control, and can be implemented for the required number of channels as defined in the project documentation.		
WL-103 – Wireless Video Systems Operation	N/A	
Verify that the operation of wireless video systems (RF and IR) is as defined in the project documentation.		

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