

Classroom Audio Visual Systems

As the cost of AV projection equipment has dropped, there has emerged a new group of suppliers promoting substandard products and installation techniques. We'll talk about what to look for in order to protect your investment in AV equipment. Customers always check the quality of the projector but rarely confirm the quality of the installation materials and techniques.

As a supplier of wire cable and other installation supplies, we see a disturbing trend away from safety and industry performance standard installation techniques, especially in K-12 installations. The Audio Visual industry and education have long been partners in teaching. During the 90's our professions diverged as large video and computer display became the "bread and butter" of the AV industry, but were too costly for widespread installation in most K-12 educational facilities. About 3 years ago the cost of small LCD and DLP projectors dropped to the point of affordability for most schools districts across the country. SmartBoards and their competitors are also driving many installations. Initiatives in many states have driven contracts for installation of thousands of these systems.

"Does it work?" "I didn't get any returns." "They were just happy to have the projectors." "It was good enough!" These are not the only measures of an acceptable installation. Building codes, the National Electrical Code and the AV industry have basic criteria for materials used to install products in public buildings that should be followed by outside contractors and by districts who chose to use district employees to install AV equipment. Some states, California for example, require contractors to have a Low Voltage Building Contractors license to do this kind of work. They may also require other licenses for installing mounts.

Educational customers have a reputation in the AV industry of not being educated buyers. In many cases schools are seen as purchasing flash rather than substance to save money. Bids are being won by lowest cost providers who guarantee their profits by taking short cuts such as providing installation materials such as wire that do not meet fire codes, cable that does not provide the signal quality anticipated, or not providing the signal distribution electronics required for a quality image. In many cases the school district doesn't have the knowledge to require the contractor or provider to perform. Many of these contractors are new to the AV industry and use materials and techniques that don't work well for AV equipment. A licensed electrician is required to provide power in virtually every state.

In many cases professional AV consultants have been hired (with success in most cases) to protect the school district from squandering large investments. However in recent years, especially in the K-12 classroom market, millions have dollars are being spent without the oversight of a qualified AV professional. For lists of AV consultants and contractors in your area, check the website of the trade organization for the International Communications Industry Association (ICIA). (Formerly National

Audio Visual Association, NAVA, who shared convention times and places with several education trade associations.)

Safety Standards

There are three areas where safety is a concern in an AV installation. First, the low voltage wires must conform to the requirements in the National Electrical Code or local building codes. Second, the projector should be mounted securely. Finally, a licensed electrician should be used to provide power at the projector location.

Low voltage wires create a great opportunity for less than scrupulous vendor to shave costs. As a result of the 1980's fire at the MGM Grand in Las Vegas, electrical codes were rewritten across the country. Deaths were caused by smoke inhalation of poison gases from smoldering wires in the heating and cooling (HVAC) ducts.

What you may not realize is that in most public buildings the space between the suspended ceiling tiles and the deck above is used to return air to the blowers of the HVAC system. This is called a plenum. Any low voltage wire in this space must be made from a special high temperature plastic (similar to Teflon).

This is called "plenum" wire and it costs considerably more than non-plenum wire. All wire installed in these spaces must be imprinted with Underwriters Laboratories (UL) or Electronics Testing Laboratories (ETL) certification and one of the three or four letter codes CMP, CL2P, CL3P or _____. Unrated or AWM rated cables are never legal. CMR, CL2, CL3 or is ***not*** legal for installation in these spaces unless the wire is in a metal conduit. (Some areas of the country including Las Vegas and New York do not allow the use of plenum cables but require all cables to be installed in metal conduit. Check your local building codes.)

The UL and ETL certification is referenced on every wire and cable with a 7 digit number starting with an "E" that must be imprinted every three feet on every certified cable. Anyone can take that number and go to the UL website to verify that the "E" number is real, and that it references the known manufacturer and type of cable. There are counterfeit cables out there that create hazards for the users. Usually they cost less than the quality cables from reputable manufacturers.

The projector mount is a little less critical, but the value of a proper mount with a good installation is hard to overestimate. The stability of the projector is critical. A little movement by the projector means a lot of movement of the image on the screen. While the vibration in many buildings makes it impossible to eliminate all image movement, a solid mount, properly installed can reduce it dramatically. In addition, proper mount will be secured to the structure of the building at more than one point. Simply securing the mount to the "T" rails of a suspended ceiling is not adequate. That creates short term hazard of not being able to support the weight of the projector and a longer term hazard in the event of a fire. The structure of a suspended ceiling may not survive a fire. Falling projectors are a significant to people still in the building and the firemen trying to evacuate them. Mounts using the "T" rails for stability are a great innovation, but require strength and safety through installation of cable to steel or concrete in the deck above.

We should not need to spend a lot of time on the requirements for a licensed electrician to locate a receptacle near the projector or other AV equipment. Long extension cords or extension cords run above ceiling tiles are dangerous on many levels. Eliminate the liability, hire an electrician. Demand to see a copy of the license.

Performance Standards

Performance standards are not legally enforceable and thus require the enforcement of a knowledgeable buyer. While the difference between a sub-standard installation and a quality installation may be relatively minor in terms of the overall cost it is certainly great enough to swing a low-cost bid to a provider of substandard material. This sub-standard material typically falls into three categories, wire gage, wire design, not supplying the electronics required by the system design and finally, scrimping on the connector and wall plate materials.

Wire

For computer graphics, the wire standard has been 26 AWG stranded, 5-conductor, 75 ohm, coax cable, for permanent installations with distances less than 50 ft. Most of the wire in the AV business for these applications comes from Belden, Extron, or Liberty. Recommendations from all these manufacturers agree: For installation, use 26 AWG stranded, 5-conductor, 75 ohm, coax cable, for permanent installations with distances less than 50 ft. In 25 years of working with reputable AV consultants, I have never seen one recommend less. Yet many firms new to the AV market make claims that their lower grade wires will “work.” Note that the cost of replacing wire that doesn’t perform is much greater than the slight additional cost from installing the right wire at the beginning. Solid conductors and thicker wire (Lower AWG) are always preferred.

The symptoms of bad cable can include:

- 1) image smear
- 2) image ghosts (Does a letter like an “I” appear only as a single vertical line or does it appear as a sharp, black line followed by several vertical lines of diminishing intensity?)
- 3) variations in brightness between horizontal and vertical lines
- 4) horizontal streaking through the image that cannot be fixed with horizontal phase
- 5) interference from outside sources such as cell phones, motors and other devices
- 6) thick horizontal bars slowly rolling vertically through the image
- 7) ultimately an intermittent image or completely failed image

Computer graphic images, VGA, XGA and greater are high resolution signals with high frequencies. XGA has a base frequency greater than 50 MHz. Experience has shown that to accurately reproduce that image a cable must be capable of transmitting 4 times that frequency while losing no more than half the signal strength. (3rd harmonic, -3 db). At about 50 ft, 26 AWG cable reaches its maximum transmission distance. 30 AWG cable reaches its this limit at about 25 ft. Higher AWG means thinner wire. The thinner the wire the poorer it transmits image detail.

All computers use Red, Green, and Blue signals to create the image. Leaving those images on three separate wires gives the most detail in the picture. In addition two synchronization signals are used to keep the picture from rolling; horizontal sync and vertical sync. Leaving them on two separate wires results in the most stable image. Consequently 5 conductors are required to adequately transmit a computer graphic image.

Coax cable is a way of building a cable so that there is a center conductor surrounded by a plastic insulator (called a dielectric). Around the dielectric there is a shield to prevent radiation of signal from the center cable, but more importantly prevent outside interference from affecting the signal on the center wire. Coax wire is chosen for its ability to transmit high frequencies with less loss than any other cable construction technique. Twisted Pair (UTP or Category) cables have greater signal loss than coax cables of a similar gage (AWG). They should not be used for computer graphics or video without the addition of a high quality balun, specifically designed for this application. We'll talk more about baluns in the electronics section below. If UTP cable is used without a balun expect most of the symptoms described above.

For video, such as a VCR or DVD the preferred methods (in order of preference) of getting a signal from the source to the projector is component video, S-Video and composite video, which are characterized by 3 cables, 2 cables and a single cable. Although the frequencies are lower, the preference for a Coax cable vs. a UTP cable remains.

Electronics

For computer graphics and video signals, all outputs and display inputs are designed to use 75 ohm cable and have 75 ohm terminations. Normally we don't need to worry about this. The exception occurs when more than one display is required. Are there two monitors? A monitor and a projector? If so, there are only two correct ways to wire the system.

In most cases the best way is to use a powered distribution amplifier or DA. You get what you pay for in distribution amplifiers. DA's allow you to display the same images on multiple monitors or projectors without degradation of the signal. They are usually as 1x2 or 1x4, which means one input and 2 or 4 outputs respectively. They are available either as stand-alone devices or built into a wall plate. An example of the latter is the Liberty PMI-A3. A laptop computer is usually designed to work with both an external monitor and the internal display without a separate DA.

Some projectors and monitors have an output for a second monitor. In these cases there may be a switch labeled 75Ω / Hi-Z. If a second monitor is used the switch should be left in the Hi-Z mode for the first monitor and 75Ω mode for the last monitor. If only one monitor is used, the switch should be in the 75Ω position. This is the second acceptable way, although it isn't always as convenient as a Distribution Amplifier.

A simple cable (wye or "Y") with one input or two outputs is **not acceptable** for any video or computer graphics signal. If the device splitting the signal doesn't have external power, it should not be used to split these signals. Using these types of devices will result in darker images, smeared images, ghosts and other image distortions.

Because audio is a much lower frequency, there electronic requirements are somewhat different. A simple cable is an acceptable way to split the output of a computer, DVD or VCR. DA's are often used by professionals to provide isolation between audio outputs although that probably isn't necessary in a classroom. A simple cable splitter should not be used between an amplifier and speakers.

Electronics are also used if the distances between the source and the display are greater than 50 ft and when the audio will be played through larger sound systems. As we mentioned earlier 26 AWG wire is acceptable for an XGA signal up to about 50 ft. At higher resolutions or longer distances electronics are used to amplify the signal and restore some of the lost high frequency information. Devices such as Liberty's PMI-A2 and PMI-A3 allow this wire to be used with SXGA signal at distances in excess of 200 ft.

Another reason for electronics is to convert the unbalanced audio signal from a source to a "balanced" signal, optimized for input to a professional sound reinforcement system. Devices such as Liberty's PMI-A2 and PMI-A3 also provide this function. A balanced audio wiring system will reduce the interference in the audio signals from outside sources such a hums, clicks, and cell phone interference.

Electronics are also useful for switching the display between multiple inputs. These devices are called switchers and can range from the very basic to the very complex. An AV professional can help you chose one appropriate to your application. They range from 2 to 100 inputs.

There are two variations to switchers that bear mention. In some situations they are combined with distribution amplifiers so that a single device can have many inputs each of which is independently switchable to one or more of many outputs. These are very useful in large systems. In smaller systems a scaler can be used in conjunction with a switcher to allow a inputs to be changed without changing inputs on the projector. In some cases this simplifies the wiring and control of the system and can be a good design option although the cost may equal the rest of the system combined!

The final use of electronics in signal distribution is as a balun. The low cost of Category cable (CAT 5e) makes it very attractive to the installer. The problem is that it doesn't match the electronics used for computer graphics, video or audio. Electronic devices called baluns can match the electronics to the wire. (For more information on Baluns, see my white paper, "Audio and Video over UTP"). A quality balun when used with quality Category cable will work, although the inherent losses in the technology may not be acceptable for all applications. In addition, category cable is much more susceptible to interference from outside sources such as cell phones, motors and florescent lights.

Of course there are many other uses for electronics in AV systems but they are well outside the scope of this article.

Connectors and Wall Plates

Professional AV systems historically have insisted on metal connectors and wall plates. The everyday wear and tear on cables makes these the most vulnerable part of any AV system. Most failures occur at these points. Molded cables are acceptable for use because of their inherent cable strain relief; however, professionals have found that handmade cables utilizing plastic connectors are simply not dependable.

For the same reason most professionals insist on metal wall plates. The length of a VGA connector makes a great lever to snap a connector out of the plastic mount. A stainless steel plate will bend. An aluminum plate will remain beautiful for years. The truth is that a high quality panel will protect your installation investment for years. They can be inexpensively custom made with the connectors and labels you desire. It is simple even to add the phone number of a help line!

While the industry uses VGA connectors throughout these systems, they are the source for many problems. They can cause ghosts in the image because their impedance is not matched to the rest of the system. The same is true of RCA and DVI-A connectors. Good system design would imply only using these connectors at the source and the display and using 75Ω connectors such as BNC connectors throughout the rest of the system. This is especially true at higher resolutions than XGA such as SXGA or UXGA.

HDMI, DVI and DisplayPort

These digital signals require special consideration since their frequencies are 10 times their analog equivalents. As digital signals they work wonderfully and should be utilized whenever possible. However when they fail, they simply don't work. Originally designed for cable lengths no longer than 15 feet, a lot of engineering has gone on to extend these signals. Today they can be extended successfully 4 ways:

1. Long HDMI cables up to 20 meters long. In some cases they can be extended to 35 meters using powered repeaters.
2. Extenders that amplify and equalize the signals on Category cable. Better results are obtained with CAT 6 cable than CAT 5e for up to 150'
3. Extenders that use 5 conductor COAX cables for up to 300'.
4. Fiber extenders for up to 1 km.

Conclusions

Sub-par materials and designs will result in sub-par images and less than reliable performance. In some cases equipment is provided that jeopardizes the safety of the students and faculty. You can protect the large investment of your school by insisting that quality materials be used to install your new Audio Visual equipment. The safety and industry standards are:

- Used licensed electricians and contractors as required by the law of your state.
- Plenum cables must be used if the wire is in most ceilings without conduit. Otherwise in-wall cable should be used in conduit AWM cable is never acceptable in the wall. Check with local regulations to confirm as this does vary by municipality and state.
- Industry standard cable is at a minimum, 26 AWG, 5-conductor, coax cable for computer graphics.
- If a monitor and a projector are required, the signal should be split between the two using a Distribution Amplifier, the signal should never be split using a "Y" cable.
- For reliability insist on metal wall plates and connectors.

- Don't use Category cable (UTP) for audio, video or Computer Graphics with investing in quality baluns to match the wire with the source and the display.

Remember the cost of fixing the problem is always much greater than doing it right from the start!

The author

Bill Schripsema is the Director of Product Management for Liberty Wire and Cable. He is CTS certified by the International Communications Industry Association. For 35 years he has professionally provided audio visual services to educational facilities, business and entertainment. He was the nerd who always ran the AV equipment in High School. He began his professional career with seven years of providing AV services at Calvin College, including system design, engineering and installation. He went on to a career of award winning television production. For the past 20 years he has worked for leading Video manufacturers and system integrators across the United States in sales, product management and system design.