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Designing For Low Maintenance
– A Set of Guidelines –

by
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1.0 Abstract

While not directly involved in maintenance, as technical consultants and system designers we feel it important to consider ongoing maintenance and operational issues during the design process. Aspects of the audio/video/automation systems design can have significant impact on maintenance from both intensity of labour and operational cost standpoints.

2.0 Environmental Issues

The environment in which the technical equipment is housed is a key factor in obtaining long-term reliability.

2.1 Power

Microprocessors and other sensitive logic circuits are now being used in all aspects of audio, video, and control systems. This equipment is sensitive to power-line problems and noise. To prevent random lock-ups and other glitches, which can be a maintenance nightmare, it is important to have a clean, isolated power source with proper grounding.

Here is the general structure of such a system in North America (specifics will vary from facility to facility):

> An isolation transformer feeds power from the main building electrical distribution bus to a dedicated technical panel.
>
> A ground is established at the secondary of this transformer, which is connected directly to a low impedance ground – this is typically the building entrance ground.
>
> In larger facilities, sub distribution panels may be provided in local equipment areas. The main distribution panel, and all sub-distribution panels, are isolated ground panels with a properly dimensioned ground conductor running back to the previous source (i.e.: the isolation transformer secondary or the main distribution panel).
>
> A separate, insulated technical ground is run to each equipment bay from the distribution panel feeding power to that bay. The equipment racks are insulated from all metallic building elements, and connected to this technical ground at one point only.
>
> All electrical outlets used for technical equipment for an area are fed from the nearest distribution panel. These must be isolated ground receptacles, with a separate, insulated ground going back to the distribution panel.
>
> Sufficient auxiliary outlets in each area must be provided from a separate panel to ensure that non-technical equipment is not connected to the technical power system.

A power conditioner will also be required if the power in your building is subject to brown-outs, surges, or line voltage fluctuations beyond ±10% of your <u>nominal</u> line voltage. If the power situation is unknown, a power line recorder should be installed for a representative period to determine if there are problems. Note that this test device only detects large-scale problems – the type of power line noise that can cause erratic behaviour in microprocessors is typically at too low a level and too high a frequency to show up on standard power line monitoring equipment.

All computer equipment should be further protected by providing an on-line UPS. Apart from providing back-up power during a power outage, these devices provide absolute isolation from most power problems.

2.2 Cooling

Electronic equipment can fail or perform erratically if allowed to operate at too high a temperature. Even at temperatures below outright failure or unreliability, the life expectancy of the equipment can be greatly reduced. Proper cooling of equipment rooms and correct rack-mounting techniques will both contribute to long-term reliability.

Some points to consider:

Modern computer systems are running at increasingly higher and higher clock rates – this translates to higher operating temperatures. If allowed to run too hot, they will often exhibit erratic behaviour.

While most electronic equipment will operate at ambient temperatures between 40 and 100°F (4 and 38°C), these are extremes, rather than design goals – operating at the upper limit will reduce component life. It is also important to note that the temperature inside an equipment rack can be considerably higher than the ambient temperature in the equipment room. Thus, the equipment room should ideally be a controlled 65-68°F (18-20°C) – to accomplish this, you need to know the heat loading of the equipment in the racks. Humidity should also be controlled to prevent condensation.

Convection cooled equipment (especially processor-intensive gear) should be rack mounted with blank panels above and below, to allow circulation around the unit. Note that some fan-cooled equipment should <u>not</u> be mounted this way (certain Crown power amplifiers are one example).

Specialty equipment (e.g.: real-time image processing computers) may have very specific cooling requirements that must be observed.

2.3 Access

As obvious as it may seem, equipment must be mounted to allow ease of maintenance and troubleshooting access – this is not always done. Some guide-lines:

Provide a minimum of 39" (1m) behind and in front of all equipment racks.

Ensure that all removable panels needed for maintenance and troubleshooting are accessible. Most rack-mount equipment can be mounted on pull-out slides to facilitate this (e.g.: hard disk video playback units, computers, etc.).

3.0 Mechanical Issues

Generally, a mechanical device will fail long before an electronic device. The more mechanically complex the device is, the more maintenance that is required. A simple rule-of-thumb for system design: <u>eliminate moving parts</u>. Clearly, this is not always possible. In these instances, ensure that the mechanisms are precision engineered and over-designed – the extra initial cost will prove to be less expensive in the long run.

Use hard-disk video and audio playback systems rather than tape transports. Avoid internal hard drives – opt for externally-accessible drives in hot-swappable bays. Keep spare drives pre-loaded with the current show files. For critical systems (e.g.: all-dome video), consider the use of RAID 3 or 5 arrays – the loss of a drive will not crash the show.

4.0 Misc. Issues

4.1 Spares

Consider spares wherever possible. Look at any items that can potentially prevent you from running a show, and, if at all feasible, purchase a spare unit (e.g.: a spare projector for all-dome video).

Modular equipment, with easily replaceable cards/modules is preferable over sealed boxes.

If a redundant power supply is offered as an option for a key component, purchase it.

Ensure that consumables (lamps, fuses, etc.) are standard items that are readily available – preferably from more than one source.

4.2 Communications

In each technical area (e.g.: equipment room, console, and pit) you should install both voice and modem lines for ease of troubleshooting and software/firmware updating. If possible, also provide high-speed internet access.

4.3 Quality

Often paying a little more initially for higher quality equipment is cheaper in the long run. Avoid consumer equipment, unless there is no industrial or professional equivalent. Use rack-mount industrial computers over desktop towers – these are generally better cooled and more easily serviced.

Understand the rated life of key components of the systems you are purchasing, and allow for their routine replacement in your operations budgets (e.g.: projector CRT's, Laser tubes, capacitors in power supplies and audio amplifiers, expensive lamps). To avoid down time, consider replacing these components on a scheduled basis (i.e.: when they reach their nominal rated life) even if they haven't yet failed.

4.4 Approvals

As independent consultants, we have for many years required all equipment that connects to AC power to have an electrical safety rating (UL or equivalent in the US, CSA or equivalent in Canada, and EC in Europe). Although this has also been required by law for many years in most parts of the world, it has not in the US – many US jurisdictions are now starting to require this (the City of Los Angeles, for example). Even if this is not a local code requirement, we strongly recommend that you insist on this.

Never accept from a manufacturer that this is impossible – there are independent testing facilities that are recognised, and most jurisdictions also have local testing authorities. This is an important safety issue – inability to get approval should set off alarm bells about the quality of the equipment. Sometimes modifications to the equipment are required to meet these standards – these most often involve grounding.

Other standards and approvals must also be met by some types of equipment. Computer equipment must meet emission standards (FCC in the US, DOT in Canada, and CE in Europe). Laser equipment must meet safety standards (ANSI Z136 and requirements of the CDRH in the US).

4.5 Preventative Maintenance

If all of these guidelines are followed, your equipment should perform reliably for many years. Sophisticated equipment, however, still requires regular preventative maintenance – following these guidelines does not negate this requirement.

Author's biography:

Garry Musgrave is Principal Consultant with Conceptron Associates, an independent audio-visual design firm located in Vancouver, Canada. Conceptron Associates specialises in the design and specification of video, presentation, audio, and show control systems. They do not sell equipment, and are completely independent of any manufacturer, vendor, or contractor.

Garry has over 20 years of design and consulting experience. He is the holder of a CTS-D (Certified Technology Specialist - Design) certification from the ICIA. He has published articles on various aspects of A/V design and technology; presented papers on show control automation, communications, and sound imaging; and written extensive user documentation for various software and hardware products. He is a member in good standing of the following professional associations:

IEEE - Institute of Electrical and Electronics Engineers
AES - Audio Engineering Society
SMPTE - Society of Motion Picture and Television Engineers
ICIA - International Communications Industries Association (Member: Design Consultants Council)
TAA - Themed Attraction Association
CSC - Construction Specifications Canada
IPS - International Planetarium Society

Over the years, Garry has been involved with the design of audio or control systems for such diverse planetaria as: the Science Museum of Virginia, Richmond, VA; the Edmonton Space & Science Centre; Bowling Green State University; Planetario de Madrid, Spain; Planétarium de Montréal; Hansen Planetarium, Salt Lake City; and the Planetario de Pamplona, Spain.

More recently, he has been involved with the upgrade of the H. R. MacMillan Planetarium (Vancouver, BC), interpretive exhibits for the Dominion Astrophysical Observatory (Victoria, BC), new exhibit galleries for the Edmonton Space & Science Centre, and the Griffith Observatory planetarium upgrade (Los Angeles).

Additional information is available on the web site at www.conceptron.com.