SPARE PARTS
HOW MANY SHOULD YOU STOCK?

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The purpose of spare parts is to minimize system downtime and losses in event of system malfunction or failure. Spare parts also help, in some cases, with troubleshooting and system diagnostics. Ten years ago, when chief electronic maintenance engineer for John Deere Co. in Dubuque, IA, responsible for reducing downtime on that company's 100 computer-controlled machine tools and programmable controls—the author recommended complete (100%) spare parts; today, as consultant to hospitals and medical electronics users, I recommend near-zero spare-parts inventory. Why?

JUSTIFYING SPARE PARTS

By properly establishing a *value* for each spare part, we can better decide to stock or not to stock, and how many to stock. The formula for establishing a value for each part is:

$$\text{VALUE} = \frac{(\text{Cost of Part})(\text{Cost of Down Time})}{\text{Availability}(\text{MTBF})}$$

MTBF = Mean Time Between Failures

As *cost of a part* goes up, so does part complexity. Further, chances of repairing it in-house go down. Therefore the value of having it on hand goes up. If the system hourly-downtime dollar figure ($D.T.) is high, this will also multiply, or increase the value of stocking spare parts. However, in the formula, the *availability* factor is divided into *cost of part times D.T. cost* because, if availability is high, the value of stocking a spare goes down.

For availability, use a figure from 1 to 100, where 1 indicates the least available (hard-to-get) parts, and where 100 indicates easy-to-get, available parts. If MTBF is high (counted in months between failures), *availability,* the value of a spare goes down. After calculating the value for several spares, the comparison of values will let one see which spares are of higher value than others.

WHAT CAUSES SYSTEM FAILURE?

One of the discoveries of the author's career is that, if you eliminate the five major stresses which cause electronic malfunction, you eliminate most system failures. As you achieve a MTBF figure nearing infinity (no system failures), the value of spare parts approaches zero. You should then stock near-zero spare parts!

The five stresses which cause electronic and computer equipment malfunction and failure are:

1. Power line surges and transients
2. Heat
3. Physical vibration
4. Oxidation and corrosion
5. Dirt build-up

ELIMINATING POWER SURGES AND TRANSIENTS

Power conditioning devices—transient suppressors, line-voltage regulators, UPS, etc., range in cost from $100 to $100,000. No single device can be considered a "cure all."

Voltage and current surges and spikes are the most frequent power disturbances, occurring hundreds of times per month. Properly engineered transient-suppression networks (many on the market are *not* properly engineered) are the cost-effective way to eliminate most computer malfunctions and failures. But such networks are rarely built-in because the technology is new and because of price competition in the small computer industry.

Most National and International Engineering Societies and governing bodies have written Transient Suppression testing and application standards, such as: I.E.E.E.-587, UL-1449, CSA, FCC Transient Standard, National Bureau of Standards, etc. IBM's PC Magazine pointed out recently that 90% of Personal Computer problems can be avoided (eliminated) by

FIGURE 1. The best way to reduce spare-parts inventory is to eliminate the causes of malfunction.

applying well-designed transient-suppression plug strips. The IBM-PC, however, has no built-in transient suppression, nor do most other PCs (except for the IBM-PC industrial-hardened version, which costs some $2,000 more than the regular PC). A good TVSS plug strip costs about $100.

DEDICATED LINE & GROUNDING

A dedicated line is not a power conditioning device, but should be mentioned because it is widely used. A dedicated line is nothing more than a separate power line brought directly from the main distribution power panel to the electronic system in question. Although it avoids the possibility of power disruptions caused by other pieces of equipment on that same line, it does not stop disruptions coming from the outside—the utility company lines, mother nature, or other equipment fed by the same main distribution panel. One advantage of a dedicated line is that it provides a dedicated *ground* from service entrance (source) to the computer system (load). By providing improved grounding, common-mode problems can be minimized, and suppression equipment operates more effectively.

ELIMINATE HEAT

A marked increase in operating stability and a decrease in maintenance downtime can be achieved if ambient temperature inside control cabinets is held between 75 to 100°F. Many installations keep their computers below 80°F at all times. (During AMEMCO surveys, small $25.00 Wahl Corp. thermometers with magnetic-mount base and peak-holding needle are mounted in electronic cabinets to detect temperature problems); some firms use a 7-day recorder (such as Weksler Type L6G1A2) to obtain room-temperature data.

Care should be taken not to over-rate the B.T.U. capacity of air. Cold air should not blow directly on circuit boards.

ELIMINATE DIRT BUILD-UP

Many electronic control cabinets, even recent models, are insufficiently sealed against contamination. Contamination can enter through wire ducts, vent panels, around switches and door edges, if they are improperly sealed. Contamination buildup will cause resistive paths, shorting between wires and board traces, intermittent disruptive failures and, finally, permanent hardware failures.

Often, cooling is achieved by circulating room air through the cabinet. This practice may get you through the new equipment warranty period, but is not adequate for long-term reliability. Dirt packs around and over components, preventing them from dispersing heat. Some dirt and fumes also contribute to corrosion and oxidation problems.

After sealing cabinets, it may be necessary to add circulating fans or an air conditioner to keep temperature below 100°F. Foam rubber strips with adhesive backing are readily available for sealing around doors and panel edges. "Duct Seal" or any non-flammable flexible material can be used to seal around cable holes and knockout holes in the bottom or top of the cabinets.

ELIMINATE VIBRATION AND OXIDATION

Electronic controllers and computers suffer when subjected to physical vibration. Solutions: Placing shock-mount pads under the control cabinet, or use rubber-center vibration-isolating bolt mounts.

Oxidation of contacts (rust) destroys connections. Friction connectors can be deoxidized by using a proper deoxidizing agent on friction connectors. Instances have been observed where oxidation buildup on older controls had become so troublesome that a control retrofit or new equipment was being considered. With the proper application of a contact cleaning solution and deoxidation treatment, however, complete reliability was restored to the controls.

Normally, application of any solution to circuit board connectors or plug pins is

discouraged for the following reasons:

1. Some solution may clean the contact, but cause faster oxidation in the future.
2. Other solutions may prevent further oxidation buildup, but will not remove existing oxidation and will leave a thin film which will attract dirt and iron-dust buildup.

The common use of an eraser to remove dirt and oxidation from pins and circuit board edge pins is *not* recommended because friction of the eraser can wear through the thin layer of gold or silver plating, ruining the conductive surface.

There is, however, one solution which has been proven effective to remove oxidation and prevent future oxidation buildup. If used according to manufacturer's recommendations, it will not leave a film to attract dirt. AMEMCO recommends *Cramolin-Red* (Caig Laboratories Inc., Escondidu, CA). Cramolin should be used rather than an eraser when reseating, replacing and cleaning circuit-board edge connectors, cable connectors, jumper-pin contacts, etc.

RESULTS

AMEMCO has helped many firms reduce failures by 90-95%: Colt Industries, Morse Fairbanks Div., Wisconsin (Diesel Generator Mfg.) has reduced electronic failures by some 92% for 1985 and 86. Cottonwood Hospital, Utah (Hospital) for three to four years, has had neither downtime nor equipment failures, compared with frequent malfunctions in the past.

Borg-Warner, Inc., California (Metal parts machining & engineering) has achieved an estimated 80-90% reduction in equipment downtime, permitting a 15% increase over previous NC and CNC equipment utilization. Baker/EIMCO-PEC, Utah (Mfr. of industrial filter media and drives) has achieved an estimated decreased NC machine downtime of 100 hours per month (from 8 Machines), representing an annual savings in downtime of $61,800.00. □

THE AUTHOR

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