Thermographic Analysis of the Central Office Power Plant

A Tool for the Maintenance Engineer

Daniel P. McMenamin

Bell Atlantic Corporation
Network Equipment Engineering
Eleven Penn Center 7th floor
Philadelphia, Pennsylvania, 19103 USA

Abstract

The reliability of the central office is, in large part, equal to that of the power plant which serves it. In normal operation, roughly a third of the system, the chargers and distribution system are in service. In an emergency, the battery and the standby sets come into play. It all must work, and work reliably. The middle of a natural disaster is a disturbing time to learn that the power plant is not all it should be. It has always been the engineer's challenge to push the limits of technology in delivering telecommunications services to his customers. With the global effort to reduce the ranks of the maintenance workforce, we test a maintenance engineer's coping skills as well as his technical acumen.

Thermographic analysis is a cost-effective addition to the maintenance engineer's "Toolbox". Modern infrared imaging systems are capable of determining the temperature of surfaces which cannot easily be touched because they are carrying lethal voltages. Additionally, they are so much faster than a thermometer, that they lend themselves to the study of low voltage equipment also.

With the increased awareness of our vulnerability to the risk of fire in the central office, a simple means of locating heat sources in the cable racks, walls etcetera is certainly welcome.

This paper will cover some of the uses to which we have placed thermographic imaging in eastern Pennsylvania. We are using it effectively to uncover potential problems, as well as to reduce maintenance cost. With this tool, we are coping with the need for increased reliability with fewer folks on the maintenance payroll.

Introduction

Our first experience in a doctor's office is, usually, finding a thermometer jammed in our mouths. In the same manner, operating temperature is a very good indicator of the relative health of central office equipment. Central offices have a massive investment in switching, signalling, transmission, and, of course, power conversion equipment. Power distribution systems are certainly in use, and most central offices have power generation and storage systems. No central office would be complete without heating, ventilation, and air conditioning systems.

Each of these systems has a correct operating temperature range. Deviation from a normal range is a good indicator of the need for attention or impending failure. Some of those failures can be pretty dramatic. Maintenance technicians and engineers are at the mercy of every weak link in the chain of systems.

Obviously, we can't jam thermometers into the equipment and cabling. Although, some of us probably remember using a felt pad and thermometer to measure heat in fuseholders and motors. Thermographic scans offer a safe, non-invasive, look at the temperature profile of the equipment.

Simple gun type devices are a cheap way to measure the temperature of large items. However, they meet the needs of firefighters and others who need to look at single entities for heat sources. Good infrared systems are expensive, but can pay for themselves with the elimination of the first CO fault with major failure potential.

By far, the best overall tool for central office use is the infrared videocamera. With this tool, a broad scan of the office is accomplished quickly. With the mix of equipment in a typical central office, one key to a successful thermographic survey program is the level of experience behind the camera. Also, the corrective actions which follow the survey. There is much to be said favoring the maintenance technician as the cameraman. This individual is better suited to correct minor defects, and refer major problems to the engineers.

Testing

A comprehensive central office scan proceeds in an orderly path through the building and it's systems. The success of the effort is, a function of the planning which precedes it. One should consider seasonal variations in building load caused by cooling systems, and the office busy period.

It makes sense to break the central office systems into subsystems scanned in turn until a profile of the office is obtained. Nearly any order works as long as everything is "Looked at" by the camera.

The commercial power service entrance is as good a place as any to start. Normally, this should be done when all major central office systems, such as chillers, etc., are running. The scan should include the conductors and especially any connectors or splices. The next logical stop might be the transformer, metering, and distribution. An engine run allows the test to include that side of the power switchboard or transfer switch. In the central offices scanned in Pennsylvania, AC distribution problems have accounted for close to ninety percent of the problems uncovered.

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The standby engine set should run with all normal and potential load. If this is impractical, consider a load bank for the test. Often, engine exercise runs are done with partial loads. A false sense of confidence becomes costly when partially blocked fuel filters, degraded cooling systems, and the like, remain undiscovered. Then, when commercial power fails, and the engine carries full load, the office is in peril. Likewise, if you can use the actual load you are better off. Load boxes are purely resistive, and can mask potential problems caused by inductive or capacitive reactance. Crosscurrents between multiple engines, for example, might not show if the power factor is unity (resistive).

An infrared "look" at the engine system itself may reveal exhaust leaks, wiring troubles, lubricant distribution flaws, and the like. This is also a good time to compare the scanned temperature of the cooling system against the gauges to verify their calibration. Scanning the start battery immediately following a start could reveal a shorted cell, since they run hot under heavy load.

If the radiator core is accessible, a scan will quickly disclose clogged heat exchange tubes because they will be cooler than those which are functioning normally. Another cooling problem is the efficiency lost when a build-up of dirt or other unwanted material obstructs the free passage of air over the exchange tubes. A scan will quickly uncover these potential troubles.

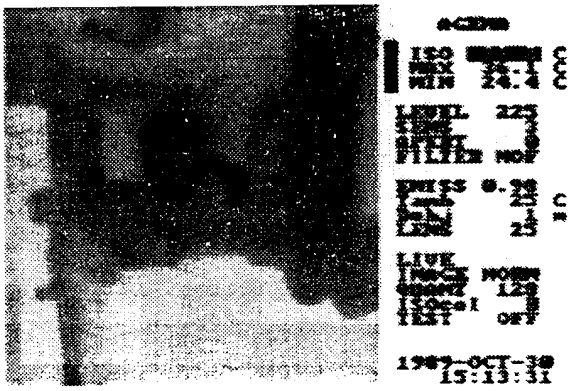
The power conversion equipment is a priority. Rectifiers under test should run as close to their full rated load as practical. In many offices, it will be necessary to turn off some rectifiers to force this. Later, the remaining units should carry load and given time to heat before scanning. Pay particular attention to capacitors in rectifiers and inverters. Many capacitor designs incorporate internal fuses. So, defective capacitors will indicate cool. This defect places additional load on the remaining capacitors. Accordingly, discovering it by thermoscan and scheduling maintenance is far less costly than waiting until catastrophic failure is the trouble indicator.

Defective diodes, triacs, and other conditions are fairly easy to identify, when some components are substantially warmer or cooler than their neighbors. Large rectifying diodes should be about the same temperature as their heat sinks, for example. If they are hotter, check for mechanical undertorquing, or insufficient heat transfer paste at the connection point.

Examine the rectifier output cabling and the plant charge bus. This assures there are no hot spots caused by poor connections or conductor undersizing.

A "Look" at the cabinets themselves is prudent. Occasionally, an air register are erroneously aimed at the top of a bottom-to-top convection cooled equipment cabinet. This causes hot air to stratify in the cabinet and results in premature failure.

The discharge bus is where many of the office's potential problems lie in wait. Fuseholders are a frequent source of trouble. Often, the trouble is a result of oxidation in the electrical contact surfaces, or the mechanical connection is loose. Modern dead-front fuseholder designs make infrared scanning the only practical way to discover these potential problems before system breakdown.



Hot spot in a 600 ampere dead-front switch & Fuse Unit. (Negative Image)

Rear of Dead-Front 31 to 60 Ampere Fuseholders Three of five fuses are overloaded by 30%. Dark Spots are heat (Negative Image)

Don't overdo the central office battery. Consider using only a partial discharge of, perhaps, twenty-percent of the battery's normal load for the test. Disable enough rectifiers to accomplish this, and wait fifteen or twenty minutes for poor intercell connections (if any) to heat. The scan will quickly identify these.

This is simply a safety measure. It is not prudent to dump the office load onto the battery unless one is very confident about it's condition. Poor connections could cause a post meltdown or even a fire if placed under full load. It is also prudent to return to float operation while running on commercial power unless the engine system has some reserve capacity.

The ground lead on metal battery stands should never be warmer than the stand. If so, check for current flow, indicative of a battery short to the stand. In low voltage telephone systems this could be a problem. In uninterruptible power systems, where the operating voltage might exceed 5oo volts, such situations are potentially lethal.

There is some merit to scanning the cable racks, since splices, "H-taps" and the like can fail in service. You may find a cable or two undersized and running warm. Parallel cables may not be sharing load due to poor connections. Battery supply cables may be running warmer than return cables, indicative of a possible ground fault.

The switchroom itself is a strong candidate for study. Examine the fuseholders in the power distribution system, and all power terminations. The bays themselves deserve a look, and hot spots examined. There could be stratification problems, poor connections, clogged air filters, shorts, improper grounds, defective filter electrolytics, and a host of other defects. The CO ground bus should not be carrying current, so these leads should be cool.

There are still a lot of the venerable, old, D1 carrier bays still in service around the world. Many of their breakdowns are directly related to hop DC to DC converters at the top of the bay. A scan would quickly reveal hot equipment caused by dead-air pockets which should be eliminated.

Sometimes during emergencies, the strangest things go wrong. When offices experience air conditioning failures it is common to place portable fans on hot equipment if the system will be down for a few days. This is a prudent time to scan around the switchroom finding hot spots which adding fans might eliminate. On the other hand, the camera may disclose that the fan you aimed at one bay is heating the next bay. An image is a more welcome indicator than a failure.

Imagination will reveal other uses for this technology. For example, in one manufacturer's digital switch product, there was a change required of a certain circuit board. Unfortunately, the faceplate identification on the packs needing replacement was identical. As it happened, the defective version of the board used significantly more power than the good ones. Identifying the boards was a simple matter of looking at them through the camera, rather than taking equipment out of service.

Although we have not done this as yet, there is every reason to believe that imaging would make a good troubleshooting tool for some circuit pack problems. If the pack was placed into an extender, the image could show unusually high current flow along foil traces. Intermittent troubles might show themselves to coincide with heat in a particular component.

Conclusion

Thermographic imaging is a tool which can "make money" in the central office. How much is limited only by the skill and imagination of the cameraman. I believe that more operating companies will use this technology, and that the price of the equipment will decrease. We will all benefit from the effort.