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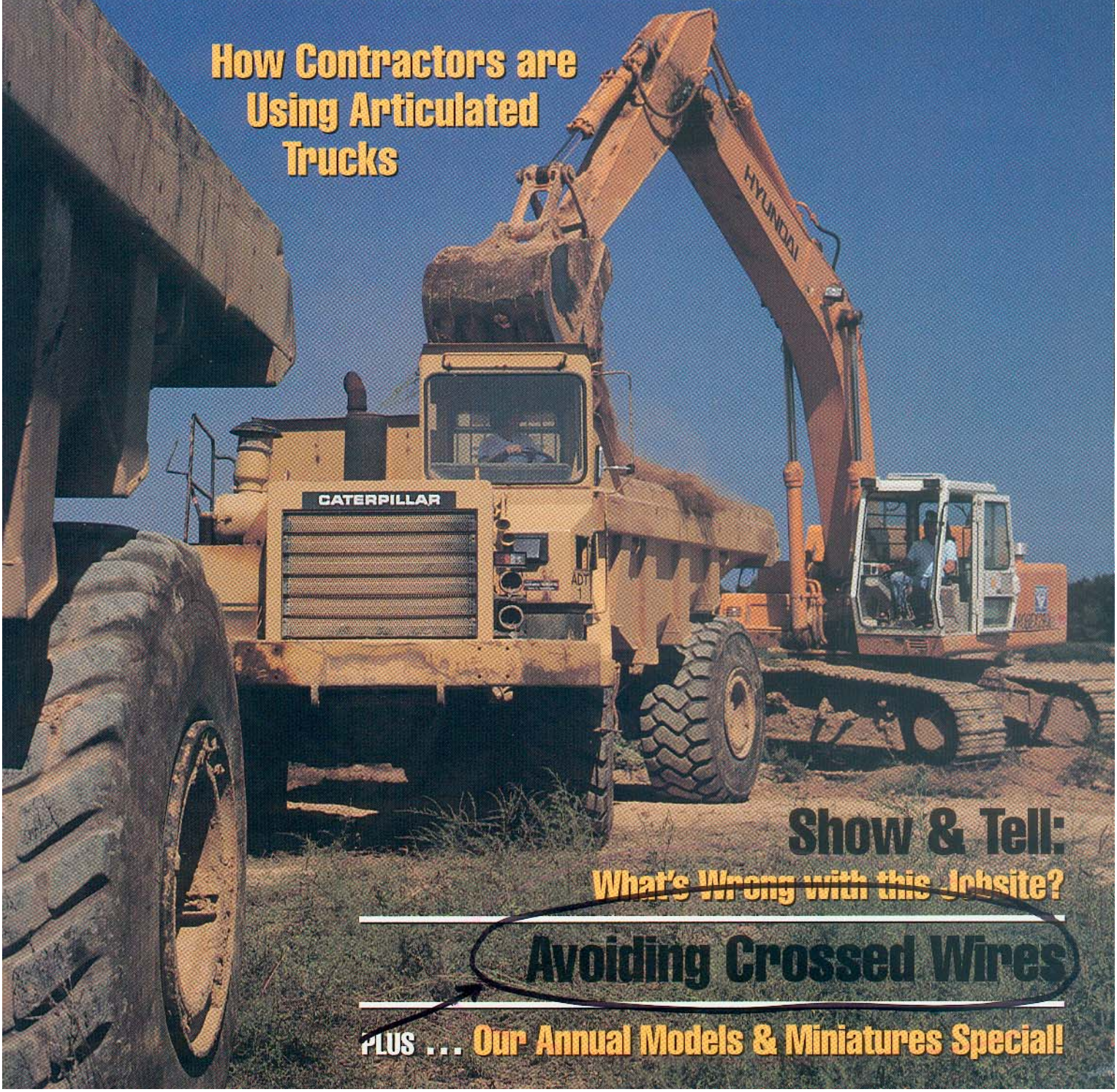

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Stay Wired

Knowledge and tools are the key to solving wiring problems • By Judith Harper

"A good technician with a voltmeter and the ability to read schematics can fix anything [electrical]," says Dennis Eudaley, electrical systems trainer for Deere and Co. Experienced troubleshooters agree that two basics — system knowledge and the right diagnostic tools — are essential for getting to the root of any electrical system problem.

Knowing the system is a troubleshooting prerequisite. According to Chris Vaught, technical specialist at JCB, this includes an understanding of the machine's basic electrical system components: battery, alternator, starter and wiring.

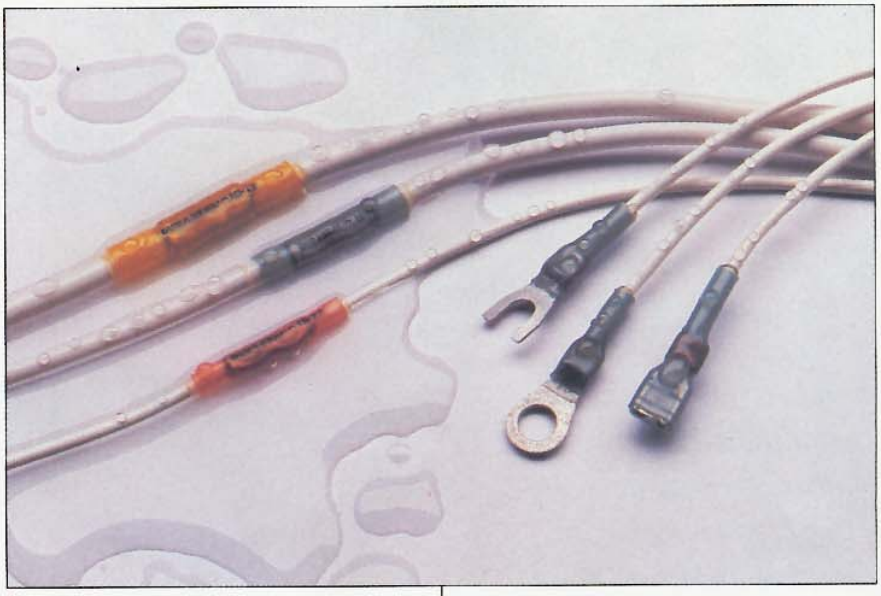
In addition, you need to understand the newer machine computer systems — how they work, and how to test them. It is essential that you understand "the strategies employed by the equipment for its operation. You need to know what you should see," says Corey Glassman, senior automotive product specialist for the Fluke Corp., manufacturer of electrical test equipment.

You can get your knowledge up to speed in several ways:

1) Read the manuals. "You need current technical manuals," says Eudaley. It's important to put this material into the hands of the maintenance personnel. "People have the tendency," Eudaley cautions, "when the books are revised and new manuals come out, to let the old manual end up with the service techs" — *not* a good idea.

2) Talk to the operator. One of the most logical sources for information about how a piece of equipment operates is the equipment operator. With the new electronic systems, Eudaley notes, "many things can happen that aren't obvious. You really have to talk to the operator to find out what really was going on when it failed. How did it fail? Was there something else that went wrong before it failed? Does it only fail after you've run it for a while? Is it temperature related?"

3) Get on and verify the problem yourself. Especially with intermittent failures, try to duplicate the conditions under which the problem usually occurs. Solving an intermittent operational problem is difficult, sometimes impossible, says Eudaley. "[When you can't] get the machine to act up, you just can't troubleshoot it."



ELECTRICAL SYSTEM MAINTENANCE

PART THREE: WIRING

HAVE THE RIGHT TOOLS

Troubleshooting and repair generally go together. You need appropriate tools to handle both.

Schematics are basic: The first of your diagnostic tools is a set of accurate schematics. "For general problems," says Vaught, "just start at the beginning with your electrical diagram and trace backwards to what's not working."

"Don't be frightened by the schematics," says Eudaley. A schematic showing 25 or 30 circuits in a single drawing sometimes can be unnecessarily intimidating. "When you've got an electrical complaint, it's probably one thing that's wrong, a fairly simple circuit. They're all tied together, but usually when something happens, it's only going to affect one or two circuits." When you're working on electronic systems, only the schematics can tell you which pin to test.

A digital multimeter also is indispensable. "With it," says JCB's Vaught, "you can check on the four things you need to check most often: amperage (draw),

This is the last in a three-part series on electrical system maintenance.

Most manufacturers have gone to protective sealed connectors. Don't destroy this protection by making an incorrect repair.

continuity, resistance and voltage."

"It's very important to get one that's going to meet all your requirements," adds Glassman. No longer restricted to digital volt and digital ohm readings, modern multimeters "do frequency and duty cycle and temperature and a number of different measurements, all of which are required for today's electronics," says Glassman.

What about test lights and probes? Logic probes — typically high-impedance instruments that have been used in electronics for many years — illuminate if the voltage is above a certain threshold. They may or may not work, depending on the application.

Test lights, even though there's at least one in every mechanic's tool box, are at the bottom of the list of preferred diagnostic tools, says Glassman. Eudaley puts it more bluntly: "Test lights are out."

The reasons for using 12V or 24V-powered test lights (lightweight, portability, and testing simplicity) are often overshadowed by reasons for not using them:

- Test lights with probes jab tiny holes in the wire. When the connection systems are subject to attack by strong chemicals, salt, or even moisture, punctures left by test light probes allow corrosion to enter and travel up the wire to pins and connectors.
- With the increasing use of electronic systems in equipment, test lights draw too much current. No problem if you're working on a starter motor or relay. If you inadvertently include electronic components in your test circuit, you wind up with burned-out integrated circuits.
- Test lights simply aren't accurate enough to pinpoint problems at the low currents at which computer circuits operate.

The tool box also should include any specialized tools recommended by the equipment manufacturer. "Good technicians always make a set of jumper leads with different connectors (and) put together their own test harnesses as needed," says Glassman.

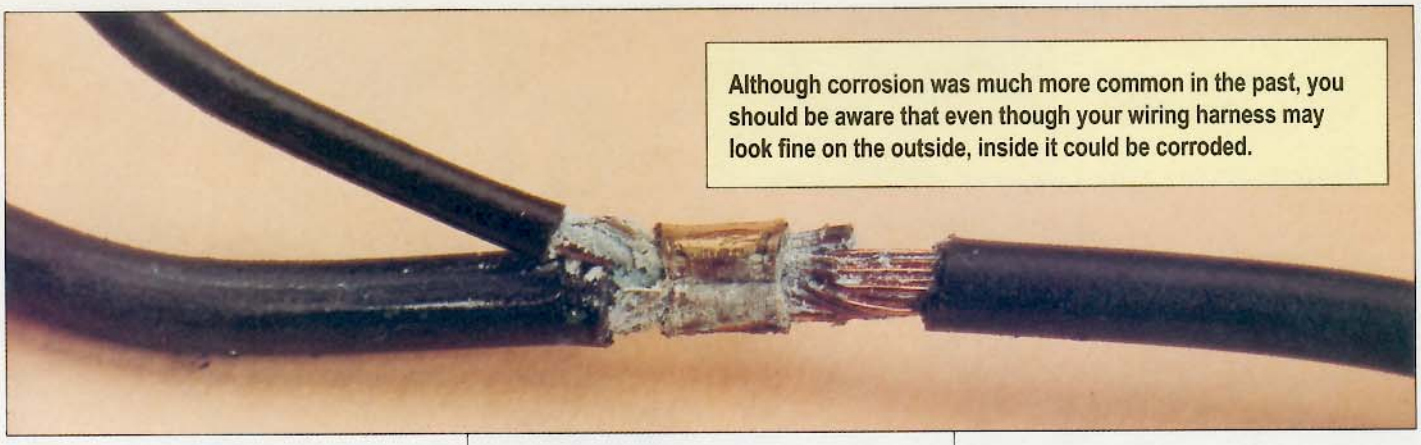
Proper repair practices are just as important as good diagnostic skills. Don't forget the electrician's standard repair tools, a good quality soldering iron and materials. Use good solder practices, or you could get in trouble. Don't solder connections; instead, use good quality crimp pliers, appropriate connectors, and heat-shrink tubing for exposed connections.

UNCOVERING THE PROBLEM: TROUBLESHOOTING TIPS

With a good knowledge of the basics, you can move confidently into troubleshooting and repair. Base your specific troubleshooting tactics on these obvious, but often disregarded, general strategies.

Start with the problem. "We recommend end-point troubleshooting," says Eudaley. "Go out to the component that isn't working. Generally that's where the problem is. Find out if you have correct voltage and good ground; then work your way back."

Begin at the trouble spot and let your knowledge of the system guide your actions, says Glassman. For example, "If the unit doesn't start, you



Although corrosion was much more common in the past, you should be aware that even though your wiring harness may look fine on the outside, inside it could be corroded.

have to know the logic sequence. What is required for it to start and run?" You need a working starter, turning at a certain speed. Then look at the starter: Is it turning? If it is, is it turning at the correct speed? If it is not, then go back a step in your diagnostic procedure and ask, "What makes the starter turn?" Answer: power from the battery ... and proceed from there.

Start where the light is brightest. "If the end-point component is buried," says Eudaley, "and you have to take 14 covers off to get to it, but you can get to a switch or connector somewhere near the mid point, then I'd start there ... where it's easiest to get to, take a quick voltage check, and go."

Routinely check voltage drop. Before condemning a malfunctioning component, check for voltage drop in the supply circuit. A circuit that is restricted (showing high resistance caused by loose or corroded connections or conductor corrosion) will not operate a component correctly. You can get this resistance in any number of different places, including body ground, alternator ground, alternator battery output, or a charging output, ground side of the battery, negative terminal over to frame rail, even at sensor connections (which typically use a much lower amount of voltage than others). It is critical to check for these resistances and correct them when necessary.

STAYING WELL-CONNECTED: PREVENTIVE MAINTENANCE

Poor connections, one of the most common causes of electrical problems, can be caused by corrosion, mechanical damage, or a combination of the two.

"Corrosion breaks the connections between components, leading to an open circuit," says Vaught. "One of the things that happens before a circuit completely opens, corrosion builds up, increasing resistance to the flow of electrons and leading to wear and tear on components."

Mechanical damage to wiring harnesses, individual wires, or connection systems can breach protective coatings and make components more susceptible to corrosion.

Using unsealed connectors or routing connection systems through harsh environments, such as in wheel wells or in high-splash areas, are primary causes of wiring system corrosion. "Five years ago, corrosion was much more of a problem than it is now," says Eudaley. Most manufacturers have now gone to protective sealed connectors.

Keep these preventive maintenance tips in mind:

1) Keep connections clean and dry. Use sealed connectors; protect all exposed connections with heat-shrink tubing.

"Most problems start when people get in and make repairs incorrectly," Eudaley says. "[They'll] hook up something new and they'll use tape connectors to add on electrical components.

"Add-on wiring must be done properly. If you do have a problem and you replace a bad connector, replace it with a good sealed connector, whether it is a manufacturer's replacement connector, a butt seal, or a wire-to-wire seal. Don't just let it corrode again."

2) On a weekly basis, check for clean connections at the battery and alternator. Clean and coat with a protective sealant.

All contact or terminations, including ground points, are at risk for corrosion. "You need to check the main connections, usually at the battery and alternator, and keep them clean," says Vaught.

3) Clean all ground points with a wire brush, and coat with sealant. "More multiple grounds are being used," says Eudaley. "Instead of grounding something right by the components, they run it up to a multiple ground." Corrosion at a multiple-ground point can cause problems in the operation of several components.

4) Check wiring harness security. Make sure the bundle does not rub against or interfere with any fixed or moving machine parts. Wiring harnesses often are secured with cable ties or

AVOIDING TROUBLE: CHECK BEFORE YOU BUY

"Design of the electrical system plays a significant role in equipment maintenance," says Alphabet Inc.'s John Norris. When you're in the market for new equipment, look for design features that make an electrical system easier to maintain and less likely to suffer from corrosion or mechanical stress problems.

Before you buy, check electrical connections. The materials used for connectors should be chemically stable and capable of sealing out corrosives. Look at all the accessible connections; ask about material specs and corrosion resistance, especially for harnesses that are not easily accessible.

Inspect and inquire about harness routing. Look for wiring that runs through more protected, less environmentally harsh areas in the equipment chassis, avoiding areas of high-corrosion risk (high-splash areas, for example).

wire ties; they can work loose and be cut or broken during mechanical repairs. Loose harnesses can chafe against bulkheads or other machine parts, wearing away their protective covering and making their wiring susceptible to corrosion. They also can dangle in the way of moving parts, which can sever them and cause a short circuit. "Short circuits are the most damaging of all electrical failures," says Vaught. "They leave the circuit unprotected and lead to machine fires."

5) Check wiring connections to be sure they are tight and dry. Check harnesses for integrity, making sure there are no frayed, worn, or cut sections. Maintain structural integrity as a barrier to the entrance of water or corrosive chemicals.

6) Use good repair practices. The electrical system is at risk even during nonelectrical repair procedures. During any kind of service or repair:

• Remove components carefully; do not pull a component connected to a wiring harness without disconnecting the wires first.

• Reconnect wires securely, making sure all connections are clean, correctly aligned, tight and dry.

According to John Norris, product engineering manager at Alphabet Inc., electrical systems are more important now than they used to be because equipment is "more electrically driven now than mechanically driven as in the past, and electrical systems are becoming more expensive." Implementing the preventive maintenance procedures outlined above can help you minimize downtime due to expensive, schedule-destroying electrical system failures.

Judith Harper is a contributing writer to Equipment World.