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Load Testing for Fire Hazards

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http://www.kennedyelectric.com/SureTest/Suretest-LoadTestingforFireHazards.htm - Link Now Dead

The NFPA reports [1] that during 1988-1992, there were an average of 483,300 fires/year in homes, resulting in 4,114 Deaths and $4.2 Billion property damage. 42,300 (8.7%) of these fires were caused each year by electrical distribution systems. Of the 42,300 fires caused by electrical distribution systems, 20,200 (48%) were caused by faulty fixed wiring, receptacles and switches.

Analysis of NFPA data and actual field studies [2] showed that the overwhelming cause of failure in faulty fixed wiring and receptacles is due to loose or poor connections and splices, damaged connectors, improper installation and ground faults.

Estimates from this data total almost 17,000 residential fires occurring every year because of loose connections/splices damaged conductors, and improper installation.

The author believes that several thousands of these fires could have been prevented and that most of these faulty circuits and receptacles could have been previously identified as hazards with a new generation circuit tester that analyzes the circuit under load.

The effect of a poor/loose connection or damaged conductor is to increase the total impedance of the circuit and cause an excess voltage drop under load. This circuit impedance is normally reported as the % Voltage drop on the circuit.

% Voltage Drop =

VoltageLine(no load) **–** **V**oltageLine(rated load)

VoltageLine(no load)

How much voltage drop is excessive? The NEC states that a maximum total voltage drop on both feeders and branch circuits to the farthest outlet that does not exceed 5%, will provide reasonable efficiency of operations. Although most receptacles and circuits fall within these guidelines, many circuits do not. Voltage drops of up to 15% (18 volts!) have been reported on some backwired (quickwire, push-in type) receptacles because of a poor quality connection.

Damaged conductors and poor splices are also major causes of high resistance connections.

For example, assume that a 15 ampere circuit has a total voltage drop of 10 volts (8.3%) at a 15 ampere load. Assume further that the circuit's normal wire and connector resistances yield a voltage drop of 6 volts (5% - the NEC reference for reasonable efficiency), and that any voltage drop in excess of that amount is attributed to a point source of resistance (poor splice, loose connection, damaged conductor). The additional voltage drop of 3.3%, or 4 volts in a 120 volt circuit, means that the loose or damaged connection has a resistance equal to 0.27 ohms, which - at 15 ampere current flow - would generate a point source of heat of 60 watts. A 60-watt point source of heat in prolonged contact with combustible material can cause ignition.

A much greater hazard potential than those provided by purely resistive loads exists with the use of induction motors, such as those used on air conditioners, refrigerators, exhaust fans, furnace fans, vacuums, etc.

For example, induction motors on 120 volt window air conditioners need up to 12-30 amperes for their full-load operation. Large units (20 to 30 amperes) are either direct-wired to the panel, or a special receptacle is installed dedicated to that installation. New wiring may also be recommended on 12 ampere-size units to ensure that the circuit will have the required ampere capacity. When new wiring is not installed, the capability of the circuit to carry the load - and whether there are other loads on that circuit - may be unknown. This unknown wiring condition exposes the installation to the danger of excessive voltage drop from unknown circuit resistance and resulting high motor current which can cause heating and possibly fire. Performing a load test on the circuit will ensure circuit integrity and its current-carrying capacity.

An induction motor has very low impedance on start-up, and draws 6-8 times its full-load ampere rating until current flows through the motor and causes the motor to develop a back-emf and higher impedance. If a circuit or receptacle has a high resistance - with a high voltage drop under load - the motor (because of low voltage) doesn't get the amperage it needs to quickly develop back-emf, and it will maintain a low impedance for a longer time. This causes periods of higher-than-normal amperage draws through the circuit during start-up, which can not only cause overheating and early burn-out of the motor - but a point resistance such as a poor splice or loose connection can become a definite fire hazard in this condition.

In the air conditioner example above, a motor with 12 amperes full load rating requires a starting current of 72-96 amps. This current will generate instantaneous heat of **1.4-2.5 KW** at the loose connection in the example above. A similar condition would occur if a 16 ampere motor were installed in a 20 ampere circuit with a faulty receptacle (high resistance connection). The instantaneous heat generated on start-up would be as high as **1.8-3.3 KW**. The fire hazard arises when the heat generated is prolonged because of the low voltage at the motor, resulting from the high resistance connections

12 ampere Motor 15 ampere Circuit	**16 ampere motor 20 ampere circuit**	
8.3% voltage drop/total circuit resistance	10 volts/0.67 ohms	10 volts/.5 ohms
5% maximum recommended voltage drop/circuit resistance	6 volts/0.4 ohms	6 volts/.3 ohms

Point resistance-of poor connection/splice	0.27 ohms	0.2 ohms
Starting current for motor	72-96 amperes	96-128
Instantantaneous heat generated at poor splice/connection during motor startup (6-8 times rated current)	1.4-2.5 KW	1.8-3.3 KW

Fixed wiring and receptacle hazards are normally hidden and cannot be identified with simple multi-meters. However, new generation hand-held testers are now available that safely impose a full 15-ampere load on the circuit for a fraction of a second - without disturbing even sensitive equipment on the circuit. This test identifies high circuit resistance resulting from loose connections and damaged conductors. A microprocessor compares measured voltages at no-load, and under a 15 ampere load - to effectively measure the circuit's resistance. The resulting voltage drop is actually a measure of the resistance of the entire circuit from the receptacle - to the panel, through the circuit breaker, electric meter, entrance wiring - all the way to the step-down transformer on the utility pole.

A voltage-drop-under-load test takes 10-15 seconds to perform using one of the new circuit analyzers which identifies deficiencies in branch circuits and receptacles. One type also calculates the current flow in the neutral resulting from the ground-to-neutral voltage to confirm whether or not an outlet is dedicated.

Testing circuits under full load is recommended by the National Association of Home Builders, Consumer Product Safety Commission and many insurance risk loss inspectors. OSHA, IAEI and many organizations teach the use of the load test in safety training seminars. The Philadelphia Housing Development Corporation and at least fifteen other municipalities now require or strongly recommend the use of the load test on weatherization projects that use blown cellulose insulation to identify high-resistance circuit connections that might cause fires.

A municipal inspector in Syracuse, NY evaluating a load test analyzer reported that 81 of the 517 residential outlets that he tested exceeded the NEC recommendation of 5% maximum voltage drop (16%), and 7% (33) of those exceeded a 10% voltage drop.

Window air conditioners, furnace fans and refrigerators operate when people are sleeping. Routine load testing on these circuits when installing such equipment and upon change of home ownership will prevent fires and save lives.

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“A load test takes 10-15 seconds.”

Footnotes

[1]Miller, Alison L. NFPA *U.S. Home Product Report 1988-1992 (Appliances & Equipment)* August, 1994

[2] Smith, Linda & Dennis McCoskrie, “What Causes Wiring Fires in Residences” *Fire Journal* Jan/Feb 1990: 19-24, 69