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BUILDING WIRING - ARE VISUAL INSPECTIONS ENOUGH ?

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

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When Loss Control Personnel are required to inspect a building's wiring as part of their underwriting responsibility, the inspection is usually a visual one only. The age and type of wiring are noted, along with the type of overcurrent protection (circuit breakers/fusing) and the general condition of the main and sub-panels. Any observed code violations and signs of “unprofessional” workmanship are also noted. If there are suspected deficiencies in the wiring as a result of this inspection, recommendation may be made to have an electrical contractor inspect or upgrade the system. Instrument testing of the branch circuits is usually not performed.

Most fixed wiring and receptacle hazards are hidden from inspection, and until recently have been difficult to identify and isolate. Unless there is a circuit interruption, normal instrument testing of a static circuit reveals little of the quality of the wiring or the integrity of the circuit. However, testing under load reveals deficiencies in circuits and receptacles that static non-load tests do not. Testing under load involves the measurement of voltages with a known resistance (load bank) on the line which is then compared to non-load readings. The resulting drop in voltage under load is caused by resistance in the wire and at point connections and splices. This voltage drop is typically reported as a % of line voltage, i.e.:

% Voltage Drop =

VoltageLine(no load) **– V**oltageLine(15 ampere load)

VoltageLine(no load)

Excess voltage drop indicates **damaged conductors**, **poor connections/splices, overlong circuits**, and/or **undersized wires**. The reduced voltage may cause damage to or malfunction of equipment (which may cause a fire), however also important, excess voltage drop generates heat - which in fixed wiring can be a definite fire hazard - specifically if the cause of the excess voltage drop is a point source such as a loose connection - and is in contact with a combustible material.

Testing under load via this procedure has been a cumbersome test which can be unsafe when performed on deficient circuits, so it has not been widely accepted. However there are now available a new generation of simple plug-in circuit testers that safely perform a 15-ampere load test to identify deficiencies in a building's wiring system. Microprocessor-operated, the instruments calculate the % Voltage drop by comparing measured voltages at no-load and while under a 15 ampere load which is imposed for a fraction of a second.

How much voltage drop is excessive? The **NEC** recommends that a maximum voltage drop on a branch circuit of **5%** will yield reasonable efficiency**.** The **IEEE** recommends that the resistance of any conductor in a branch circuit should **not exceed 0.25 ohms.** A complete circuit of 2 conductors - or maximum total of 0.5 ohms - would yield a voltage drop of **6.2%** under a 15 ampere load on a 120 volt circuit.

Assume that the total voltage drop on a circuit is 8.3% at a 15 ampere current flow, and that the circuit has a resistance equal to the NEC recommended maximum voltage drop of 5% as a result of normal wire and connector resistances. Assume further that any voltage drop in excess of that amount is due to one concentrated source (connection, splice, etc), then the loose or damaged connection has caused an additional voltage drop of 3.3% or 4 volts in a 120 volt circuit. This additional resistance of 0.27 ohms would generate a point source of heat of 60 watts at a 15 ampere current flow. A 60-watt point source of heat in prolonged contact with combustible material can cause ignition.

The NFPA reports [1] that during the period 1989-1993, an average of more than 162,400 fires/year occurred in non-residential structures, resulting in $2.9 Billion of property damage and 205 deaths. 16,600 or 10.2% of these fires were caused annually by electrical distribution systems. Although there is no further breakdown of the cause of fires in electrical distribution systems in non-residential structures, in-depth investigation of 149 residential fires caused by electrical distribution systems showed that the largest portion of these fires (53%) were caused by faulty fixed wiring, receptacles and switches. An article by Smith & McCoskrie [2] summarizes the results of this investigation.

Of the fires occurring as a result of:

- **Faulty fixed wiring -** poor or loose splices, damaged connectors, improper installation and ground faults accounted for **94%** of these fires.
- **Receptacles and switches -** loose or poor connections accounted for **59%** of these fires.

Considering the 16,600 fires that occur annually in non-residential structures, most of those faulty circuits and receptacles could have been previously identified as hazards by testing the circuit under a 15-ampere load, and the very real probability exists that **several thousands of these fires could have been prevented!**

The **Philadelphia Housing Development Corporation** requires contractors to perform the voltage drop under-a-15-ampere-load test prior to insulating existing homes. [3] Prior to instituting the test, smoldering fires were associated with half a dozen installations which consisted of blowing cellulose insulation into the attic crawl space of existing row homes. The PHDC found that 70% of the homes flunked the 5% threshold on the voltage drop test with "a cluster around 6%". They arbitrarily established **10%** as an unacceptable voltage drop, beyond which the contractor must repair/replace the circuit prior to proceeding with the insulation project. PHDC has been using this criteria successfully for more than 2 years.

Testing wiring circuits under full load is also recommended by the **Occupational Safety & Health Administration** - who teaches this test in OSHA safety classes at the OSHA Technical Institute in Des Plains, IL.

After using the Voltage-drop-under-15-ampere-load test for eight months, the **National Assoc. of Home Builders** Research Center stated ***"Because the tester is able to quickly and safely apply a full load test to the circuit, we can test all circuits in a house for hidden, sometimes deadly flaws within minutes"***. Simple-to-use, the tester **isolates hazards** using simple logic as the inspector moves along the branch circuit.

Based on the ease of use of this test, the **Consumer Product Safety Commission** recommended to the NFPA 73 review committee - the inclusion of the 15 ampere load test in NFPA 73, the inspection procedure for one and two-family dwellings.

The increased use of non-linear loads resulting from increased use of switch-mode power supplies increases the loads to be carried by branch circuits. With this trend and the fact that wiring deteriorates due to aging, the likelihood increases that fires will be initiated by faults in fixed wiring and receptacles.

An insurance loss control inspector in Merced, California reported the below summary of outlets tested during use of a load test circuit analyzer for two months:

Voltage Drop	Apartment	Commercial	Industrial	Total
< 5%	27	39	27	**93**
5.0 - 5.9	1	2	2	**5**
6.0 - 6.9	2	2	1	**5**
7.0 - 7.9	1			**1**
8.0 - 8.9		1		**1**
9.0 - 9.9				
Total	**31**	**44**	**30**	**105**
No ground	**4**	**5**	**2**	**11**
Rev Polarity	**2**	**2**		**4**
False Grnd	**1**			**1**

Total outlets tested = 109**.** No Load test readings were taken in 4 of the ungrounded outlets

Only a few outlets were tested at most risk locations and deficiencies were noted for corrective action. The inspector concluded that, ***"By performing a full-load test, I feel a lot more comfortable signing off on the acceptability of a building's wiring system."***

A municipal inspector in Syracuse, NY reports the following distribution of test data:

Voltage Drop	Residential	Commercial	Industrial	Total
< 5%	436/84%	87/94%	13/100%	**536/86%**
5.0 - 10	48/9%	4/4%	0	**52/8%**
> 10%	33/7%	2/2%	0	**35/6%**
Total	**517**	**93**	**13**	**623**

In the Syracuse data, it is the opinion of the inspector that the combination of multiple spices and loose/improper joining techniques are the greatest causes of (excessive) residential voltage drops, and circuit length/splices for commercial.

Another possible cause of the high resistance readings in residential situations is the greater likelihood of use of the “quick connect”, push-in type connectors by do-it-yourself installers. Several municipal inspectors reported high % voltage drop readings (as high as 12%) when testing receptacles with the push-in type “quick-connectors”. In every case reported when the connection was changed to the alternative screw connector on the receptacle, the voltage drop readings fell to within acceptable levels.

Another very useful test performed under load is the measurement of ground impedance. Although a standard “outlet tester” may indicate that a receptacle is “grounded”, it cannot indicate the quality of the ground. By testing under a 15 ampere load, the new circuit analyzers calculate and display the ground impedance in ohms (IEEE recommends no more than 0.25 ohms). Loose connections or other causes of inadequate grounding not only are hazards because of inadequate fault current paths, but they often render useless the protection of computers and other expensive equipment by devices that rely on a good quality ground.

Ease-of-use is important to the loss control inspector. The new generation circuit analzers take only seconds to test each outlet and circuit under a 15 ampere load and quickly identify hazards due to loose connections, inadequate grounding, bad splices and damaged conductors in addition to also detecting incorrect wiring, false grounds (the illegal connection of ground-to-neutral at the outlet), and measures the exact trip point of a GFCI (in ma) - independent of line voltage variations.

The dynamic testing of branch circuits under full load has been proven to be effective at identifying hazards and is fast becoming the preferred method. The identification of deficiencies in branch wiring and receptacles and the isolation of hazards can prevent thousands of fires and/or reduce claims/identify high risks if used routinely by loss control inspectors.

The author is president of Industrial Commercial Electronics in Buffalo, NY, manufacturer of SureTest® circuit analyzers. (800) 442-3462.

Footnotes

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

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

[3] Kinney, Larry "Assessing the Integrity of Electrical Wiring" *Home Energy* Sept/Oct 1995: 5,6