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TRIAL BY FIRE

IF you think metallic conduit protects electrical circuits longer than non-metallic conduit... you could be dead wrong.

Published reports, over an extended period of time, indicate that steel conduit ground faults are a factor and cause contributing to fire situations. The tests in this report—"Trial by Fire"—document this finding.

TRIAL BY FIRE.

When fire breaks out every second counts. Recent fire tests, conducted by an independent testing laboratory, show that Electrical Non-metallic Tubing (ENT) and PVC Conduit protect electrical circuits longer than Electrical Metallic Tubing (EMT) and Intermediate Metallic (IMC) Conduit.

Test objective—Test No. 1

To compare the ability of two equal lengths (10-foot long test specimens) of 1-inch diameter (nominal) EMT and ENT conduit to protect the circuit integrity of current-carrying electrical conductors while subjected to intense heat and flame generated by a kerosene ignited wood fire.

Test objective—Test No. 2

To compare the ability of two equal lengths (10-foot long test specimens) of 1-inch diameter (nominal) IMC and schedule 40 PVC conduit to protect the circuit integrity of current carrying electrical conductors while subjected to intense heat and flame generated by a kerosene ignited, wood fire.

Summary—Test No.1

Elapsed time of Test No. 1 was 9 minutes. During Test No. 1 all circuits in both test specimens failed during the first six minutes of the test.

As shown by panel 1, all 10 circuits (green indicator lights) in the ENT conduit, and all 10 circuits (red indicator lights) in the EMT conduit were functional at the beginning of the test at 2:24. Panel 2 shows the first circuit failure in the EMT conduit at 2:27 three minutes into the test. Two additional EMT circuit failures followed rapidly (see panel 3).

At 2:28, four minutes into the test, all 10 circuits in the EMT had failed (panels 4 & 5). ***Significantly, not a single circuit in the ENT conduit had failed at this time.***

At 2:29 (panel 6) the first circuit in the ENT conduit failed. At 2:30 (panel 7) all the remaining circuit indicator lights monitoring circuit integrity in the ENT conduit extinguished.

NOTE: The remaining circuits in the ENT conduit went dark simultaneously indicating a main fuse failure.

Summary—Test No. 2

Elapsed time of Test No. 2 was 17 minutes. All circuit indicating lights monitoring the circuits in the IMC conduit had gone dark within four minutes. Nine circuit indicating lights monitoring the circuits in the schedule 40 PVC conduit had extinguished within 10 minutes. One circuit indicating light continued to function until the test was terminated after 17 minutes.

As shown by panel 1, all 10 circuits (red indicator lights) in the IMC conduit and all 10 circuits (green indicator lights) in the schedule 40 PVC conduit were functional at 4:08 one minute into the test.

As shown by panel 2, at 4:09, 2 minutes into the test the first circuit failed in the IMC conduit. The second circuit in the IMC conduit failed at 4:10 (see panel 3) followed by two additional circuit failures in the third minute of the test (see panel 4). At 4:11 (see panels 5, 6, and 7) the remaining circuits in the IMC conduit failed. ***Significantly, not a single circuit in the schedule 40 PVC conduit had failed up to that point.***

At 4:14, seven minutes into the test, the first circuit in the schedule 40 PVC failed, quickly followed by a second circuit failure (panel 9), followed by five circuit failures at 4:15 (panels 10 and 11). Two of the remaining three circuits in the schedule 40 PVC failed at 4:18 (see panels 12 and13). The last remaining circuit in the schedule 40 PVC conduit (panel 14) remained illuminated when the test was terminated at 4:24.

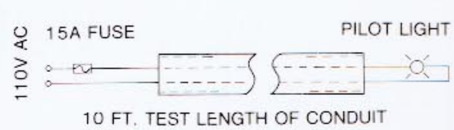
Test set-up

All conduit test specimens were 10-feet in length. Individual conduit sections were tested in pairs. Test No. 1 paired EMT and ENT sections. Test No. 2 paired IMC and schedule 40 PVC. All test specimens were 1-inch diameter (nominal) sections of standard material. The paired sections were spaced 6-inches apart and supported with angle iron on 3-foot spans. The angle iron was bolted to a cement board attached to a metal fence.The test area was blocked on three sides by a building and 4 x 8-foot sheets of gypsum board. Both test specimens in both Test No. 1 and Test No. 2 were equidistant from the fire bed.

Wiring

Each individual test specimen was wired with 10 two-wire circuits consisting of 10 hot wires (black) and 10 neutral wires (white). All wire was #14 AWG type THHN. Grounding on the PVC conduit consisted of a green #14 AWG THNN equipment grounding wire pulled through the conduit along with the 10 pairs of conductors. The ground wire was connected to the ground terminal of a 30 amp branch circuit power source. Grounding of the IMC conduit consisted of a green # 14 AWG THHN wire connected to the ground terminal of a 30 amp branch circuit power source which was then firmly clamped to one end of the IMC conduit. Grounding of the ENT conduit consisted of a green #14 AWG THHN equipment grounding wire pulled through the conduit along with the 10 pairs of conductors. The ground wire was connected to the ground terminal of a 30 amp branch circuit power source. Grounding of the EMT conduit consisted of a green #14 AWG THNN wire connected to the ground terminal of a 30 amp branch circuit power source which was then firmly clamped to one end of the EMT conduit.

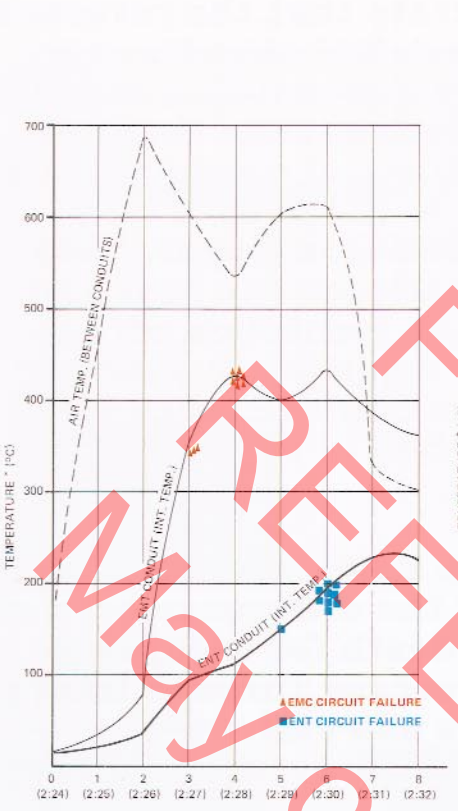
One end of each circuit was wired to a 110 volt, neon panel indicating light. The other end of each circuit was wired to a15 amp, quick-melt Buss fuse. Panel lights were displayed on a panel in two sets of ten, one set for each conduit. As any individual circuit failed, the corresponding panel light would extinguish.

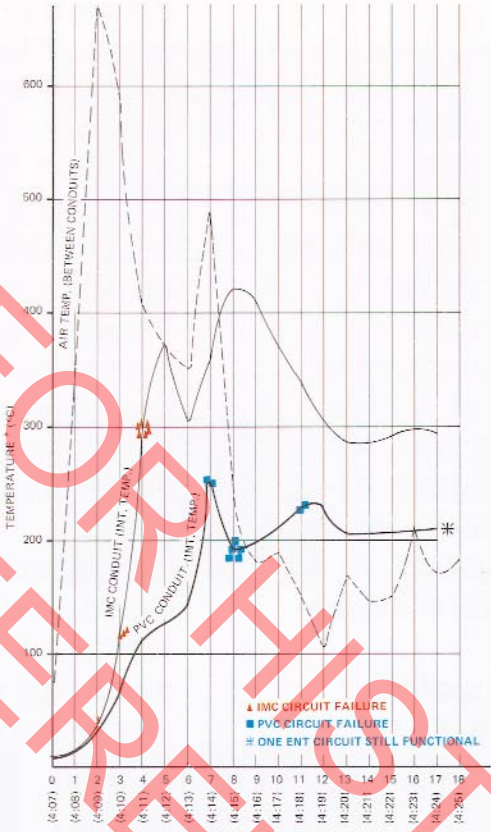


Wiring diagram—typical test circuit

Fuel

The wood crib fire source consisted of 24 layers of 18 x 3 x 1-inch dried pine boards. The





TEST NO. 1 **TEST NO. 2**

TIME VS. TEMPERATURE CURVES (SEE CURVES FOR IDENTIFICATION)

Temperature curves plotted from the test data show that after two minutes of exposure to the flames, the internal temperature of the metallic conduit far exceeds the internal temperature of the non-metallic conduit which does not conduct heat as readily.

*Conduit temperatures are measured internally by IC thermocouples placed inside the individual test sections. Air temperatures are measured by IC thermocouples outside and equally spaced between the conduit test sections. (Thermocouple and thermocouple shield can be seen in photos beween conduits.)

boards were stacked 3 to a layer with the next layer perpendicular to the previous one. The finished wood crib was approximately 18 x 18 x 18-inches with the top of the crib 2-feet below the bottom of the horizontally laid conduit. The crib was centered under the center 3-foot span of the 10-foot conduit test specimens. One-half gallon of kerosene was used to ignite the fire.

Results And Conclusions

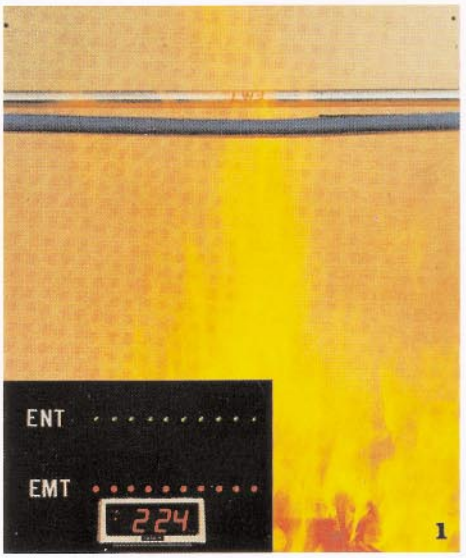
The conduit materials were evaluated in pairs in order to make a direct comparison between the different types of materials tested; EMT and ENT, IMC and PVC.

As could be expected, when the air temperatures in both test rose to in excess of 600°C, the internal temperatures of the test specimens, as measured by their respective thermocouples, also rose sharply. The slope of both the EMT and the IMC curves, however, were greater than the slopes of their non-metallic counterparts and the internal temperatures of the metallic test specimens, in both tests, were considerably higher than the temperatures measured in the non-metallic test specimens (see time vs. temperature curves Test No. 1 and Test No. 2).

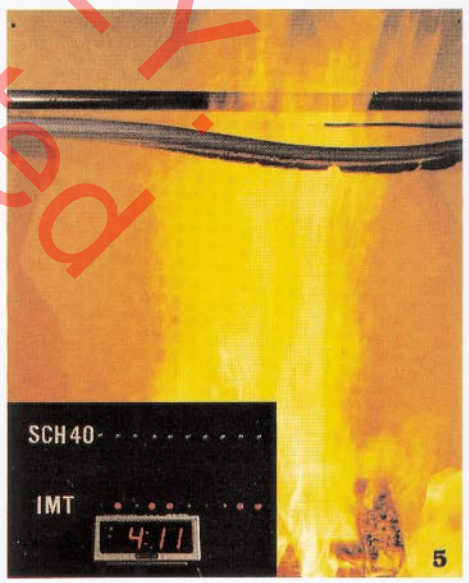
It is significant that, in both tests, all the circuits in the metallic test specimens failed before the first circuits in the non-metallic test specimens. The high internal temperatures recorded in the metallic test specimens would indicate that the metallic conduit acts as a heat conductor. The higher the internal temperature in the conduit, the greater the possiblity that the insulation surrounding the conductors will break down causing them to short out either by touching the conduit wall, or each other.

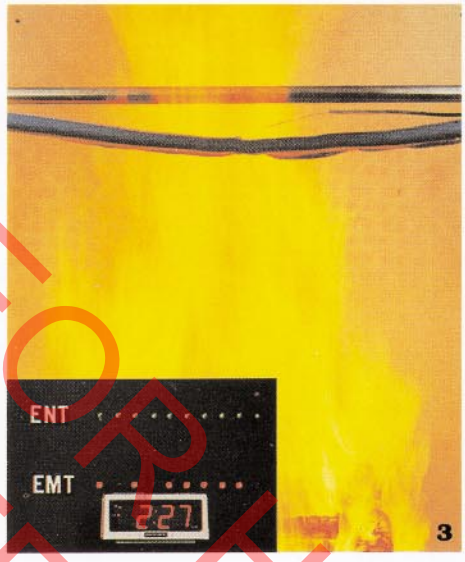
Additionally, the non-metallic conduit, in both tests, did not add to the propagation of the fire either by flame spread or dripping.

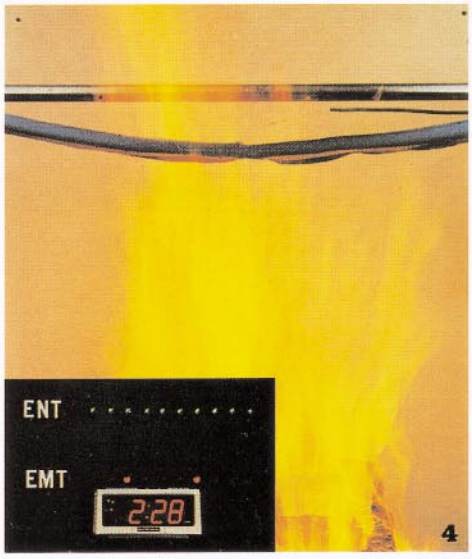
Test No. 1 ENT vs. EMT



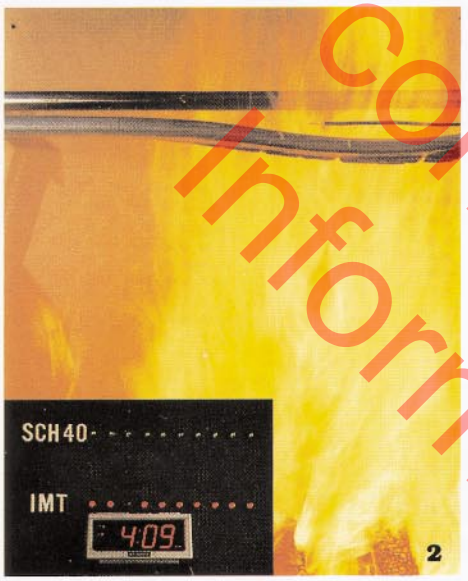
Test No. 2
Schedule 40 PVC vs. IMC

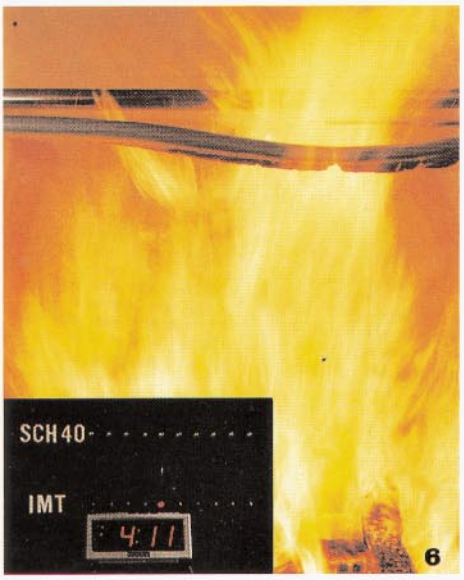


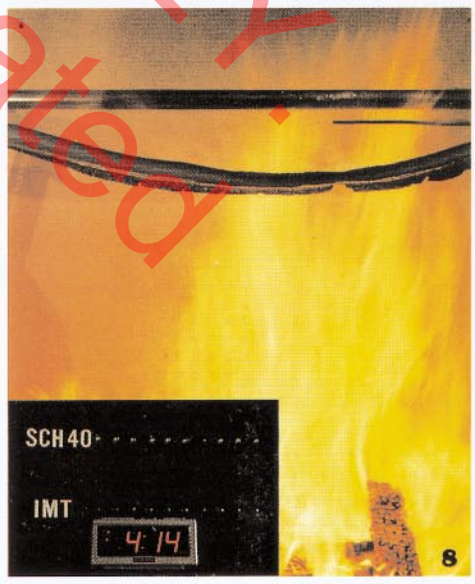




Test No. 1—Continued on Pg. 5

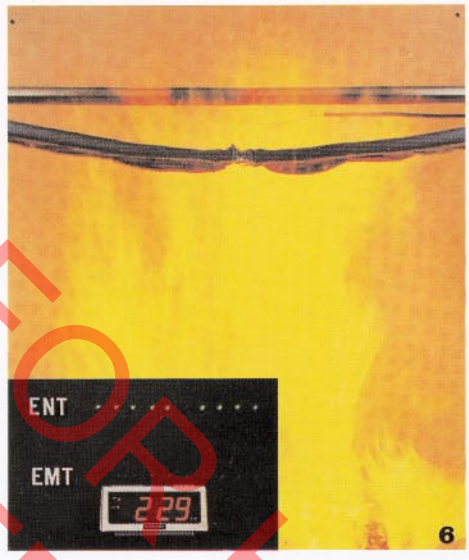


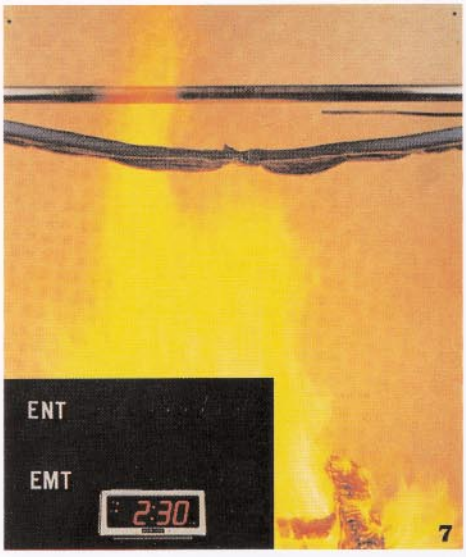




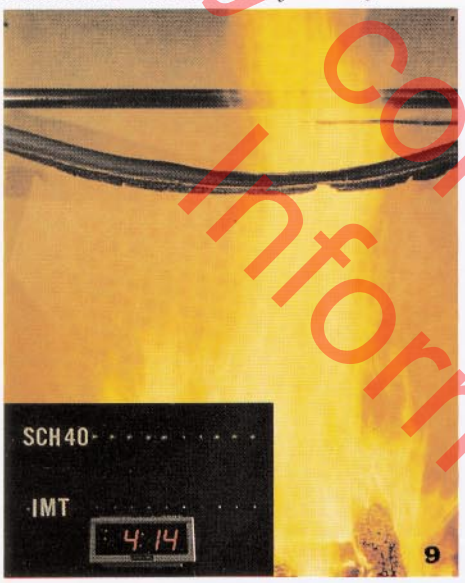
Test No. 2—Continued on Pg. 5

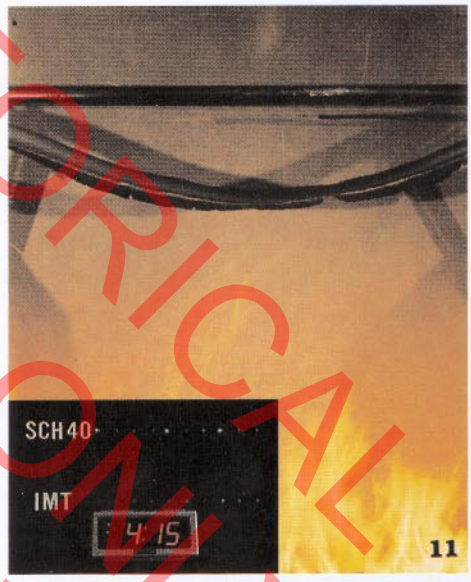
Test No. 1—Continued from Pg. 4

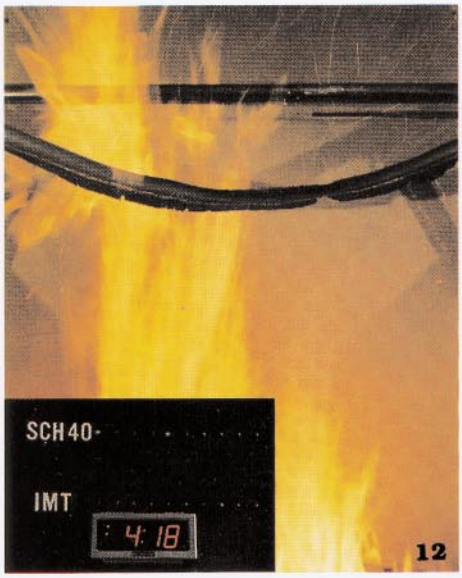


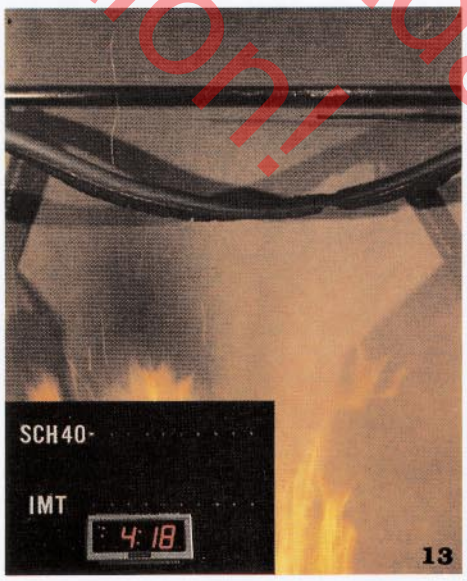


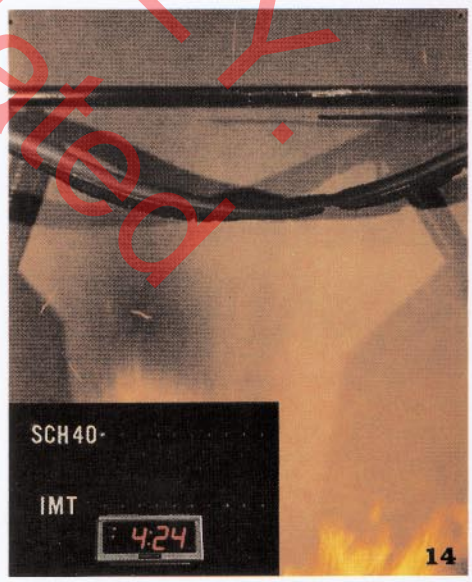
Test No. 2—Continued from Pg. 4











When fire breaks out... Every second counts!

In modern structures, with greater dependence on electrical power for signal systems, stairway illumination, and other vital functions, every extra minute the power stays on means safer, easier, more orderly evacuation in event of a fire.

Traditional thinking has held that metal conduit systems afforded better protection to electrical conductors than non-metallic conduits in a fire situation.

Tests recently conducted now challenge that idea and demonstrate that the reverse is true. Electrical circuits protected by non-metallic conduit operate longer than those installed in metal conduits when exposed to the heat of a fire—critical minutes longer. Metal conduits absorb the heat and "cook" the insulation off conductors, resulting in shorting and circuit failure much more rapidly than in non-metallic conduits.

These extra minutes can, indeed, be the difference between life and death for occupants seeking escape through internal corridors and stairways.

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