Choosing Household Wiring for Low EMF

by Andrew Eriksen

from left to right: ROMEX 12/2, ROMEX 12/3, EMT conduit, IMC conduit, MC 12/2

Modern buildings have electrical wiring in all walls, and often in ceilings and floors as well. As electricity runs through the cables to be consumed elsewhere, an electromagnetic field [EMF] is generated. This field surrounds the cable in its entire length and becomes weaker with increasing distance to the cable. Electromagnetic fields are bothersome to some individuals and can be measured by a gaussmeter.

When wiring a new building, or upgrading an existing building, it may be prudent to choose a type of cable that emits less EMF, but which one to choose?

To find out, a selection of cables and metal conduits were purchased. Only types that are widely available and in general use in the United States were chosen. The cables tested were:

- ROMEX 12/2 (2-conductor, AWG 12)
- ROMEX 12/3 (3-conductor, AWG 12)
- MC 12/2 (flexible metal-clad, 2-conductor, AWG 12)

The conduits tested were:

- EMT - lightweight steel conduit
- IMC - heavy steel conduit

The AWG 12 thickness of the wires were chosen, as they are used for household wiring carrying up to 20 amps.

A Wiring Primer

In the electrical trade, the grounding wire is always present in a cable and is not counted as a conductor. A "2-conductor cable" thus has three wires inside – a black one for the phase, a white for the neutral, and a bare copper wire for the ground. In some cases, the ground wire is green instead of bare.

A 3-conductor cable has one additional wire, which is usually red. This type of cable is commonly used for bringing two-phase (230 volt) electricity to electrical stoves, clothes dryers and water heaters. It can also be used for lighting circuits with two switches, such as in each end of a hallway.

Test setup

A combination of cables and metal conduit were tested under identical conditions. To provide a test load, a 1380 watt space heater of brand Intertherm (now SoftHeat) was placed approximately 20 feet away.

The metal conduits tested were sold in 10-foot sections, but we used six-foot samples due to transportation restrictions. The measurements were done at the middle of the conduit. In all tests, the ground wire in the cable was connected to the ground in the wall outlet, as it normally would be.

The ROMEX 3-conductor cable tested was used without connecting the extra wire to anything. It was not tested whether connecting it to the ground would be helpful. Doing so would violate the National Electric Code, which is very specific about the color codes, and forbids running wires in parallel.

To limit outside interference with the test, a specially shielded outlet was used, while the breakers were off to all the other outlets within twenty feet. The outlet used had regular wiring inside EMT metal conduit, which went all the way back to the breaker box.

The EMF levels were measured by a gaussmeter of the TriField brand, produced by Alpha Labs in Utah. The TriField meter was outfitted with the optional external

probe that makes it one hundred times more sensitive and able to pick up EMF down to 0.01 milligauss.

The 120 volt AC power in the building did have some overlying static ("dirty power") which could be picked up with an AM radio. This static was present whether any current was running or not. It appeared to come from the outside of the building and this was deemed not to be a problem for this comparison.

Results

The results from the gaussmeter readings are shown in Table 1. It is clear that the 3-conductor ROMEX wire (ROMEX 12/3) is vastly superior to the 2-conductor (ROMEX 12/2). This is due to the fact that the individual wires inside the cable happen to be twisted around each other. This effect is used in wires for computer networks and long telephone cables, so it was not a surprise that it also worked well here.

What was surprising was that the ROMEX 12/3 cable also is superior to the other cable combinations tried, i.e. the flexible metal-clad cable (MC 21/2) and when the ROMEX 12/2 was put in metal conduit and even when put in the heavy duty IMC conduit.

When the ROMEX 12/3 cable was further shielded by EMT conduit, the radiation level become so low that it only measured 0.4 milligauss directly on the surface of the conduit.

Table 1: Distance in inches from cable for specific EMF levels

	1 milligauss (0.1 microtesla)	0.2 milligauss (0.02 microtesla)	0.01 milligauss (1 nanotesla)
ROMEX 12/2	10.5	18.5	37
ROMEX 12/2 in EMT	3	6.5	25
ROMEX 12/2 in IMC	2	5	15
ROMEX 12/3	0.6	1.7	3.3
ROMEX 12/3 in EMT	--	0.7	2
MC 12/2	1.5	2.3	3.7

Conclusion

If wanting to wire a house for lower EMF levels, using the 3-conductor twisted ROMEX 12/3 (or any other suitable AWG size) is clearly a good choice. It is about ten times as good as the standard 2-conductor ROMEX wiring.

The extra cost of using a 3-conductor cable is minor; it just costs somewhat more due to having more copper in it. The price was very close to the cost of the metal-clad MC cable, and much cheaper than using the rigid metal conduits (EMT and IMC) as they are much more labor intensive to install.

It is only when combining the 3-conductor cable with a metallic conduit that even better results are possible. Whether going this route is cost-justifiable must depend on the project; in most cases it probably is not.

Putting the 3-conductor cable in metal conduit may be a violation of the National Electric Code, NEC, even if one wire is never used (the reason is that the extra wire could later carry more power, which could generate more heat, which is the basis for the NEC). Discuss the project with the local building inspector.

An alternative to using the 3-conductor cable is to convert a 2-conductor cable by twisting it. This would be a little cheaper and should not cause any potential issues with the building inspector.

The tested 3- conductor ROMEX cable did a full turn of the wires inside it for every four inches (10 centimeters) of running cable. This twist could be duplicated by hand – perhaps by using a variable-speed (low speed) power drill with a bent nail in the chuck to hold the cable. A non-electric set up should also be possible.

Twisting the cable more than once per four inches may improve the shielding effect. The author has not tested these possibilities.

A Comment for the Chemically Sensitive

Some manufacturers of ROMEX type cables add a slippery coating on the surface of the cables. This coating makes it easier to pull the cable through a conduit, but it can be bothersome to sensitive individuals. The author tried to leave a sample in the desert sun for one month, but it was still bothersome.

Cables made by Southwire have this coating, which is called SIMpull. Another manufacturer, Encore, does not use such a substance. If the local building supply store only stocks ROMEX with this coating, try an electrical supply store.