Metal rooms magnify radiation from wireless devices that are inside

We tested whether microwaves from a small wireless device gets "trapped" and bounce around a metal room. We found that they do, exposing people to radiation levels that can be ten times (or more) stronger than if outside.

We also tested to see if large windows and open doors would let the radiation "escape," and found that it does not.

Then we checked to see if microwaves could enter the metal room through unshielded doors and windows and be "trapped" inside. We found that there is a small such effect if the transmitter is very close, such as when a person stands right outside with a mobile phone. But once the transmitter is further away, then there is no such effect.

We found that metal buildings and metal rooms provide protection against outside transmitters, such as cellular base stations. They provide better protection than buildings made of non-metals, such as wood, brick or concrete.

Keywords: *radio frequency radiation, RFR, microwave radiation, RF, metal room, metal building, metal house, reflection, shielding, trapping, Faraday cage*

Reflecting radiowaves

When someone uses a cordless phone, mobile phone or wireless network inside a building made of plywood, gypsum drywall, bricks or plastic siding, the radio waves simply pass out through the walls. People in the building can limit their radiation exposures by keeping a distance to these sources, as the radiation gets lower when further away.

Metals such as aluminum, copper and steel reflect radiowaves instead of letting them pass through. This effect is used in satellite dish antennas to gather and concentrate a weak signal. It is also used to shield rooms and entire buildings to prevent spies from snooping, to protect against electronic weapons and to protect sensitive people against electropollution. This is called a Faraday cage.

There are also many building products that happen to be metallic, either as plates, foils or coatings. Steel plates are commonly used to cover the facades of industrial buildings and highrises. Some buildings have roofs of steel.

In some parts of the world, such as Australia, it is common to install aluminum foil as a heat reflector inside the walls and in the attic of all types of construction.

Energy-efficient "low-E" glass has a thin metallic coating. These windows are used in both offices and in private homes. Some office buildings have entire facades covered with these metal-coated windows.

People with severe environmental sensitivities commonly cover walls with foil to limit their exposures to fumes from the paint, drywall, insulation, etc. Some have custom built houses made almost entirely out of metal, as they are often the best tolerated material and require very little upkeep with toxic products such as paint.

We wondered how much reflected radiowaves would raise the radiation level if bouncing around inside a room with metallic walls. Would the waves bounce a few times and quickly leak out through the various holes and slits around doors, windows, etc.? Or would the waves keep bouncing around and thereby dramatically raise the radiation level inside?

The first test

We used a small microwave transmitter and an RF meter in our tests. First we placed the transmitter out in a yard where the ambient radiation level was very low. There we measured the radiation from the transmitter at three distances (6 ft, 10 ft and 20 ft) or (2 m, 3.2 m and 6.5 m).

As expected, the radiation rapidly got smaller with increasing distance. We used these numbers as a baseline to compare with.

Then we did the same measurements inside three houses that were all built with steel siding, steel roofs, steel doors and had walls covered with aluminum foil.

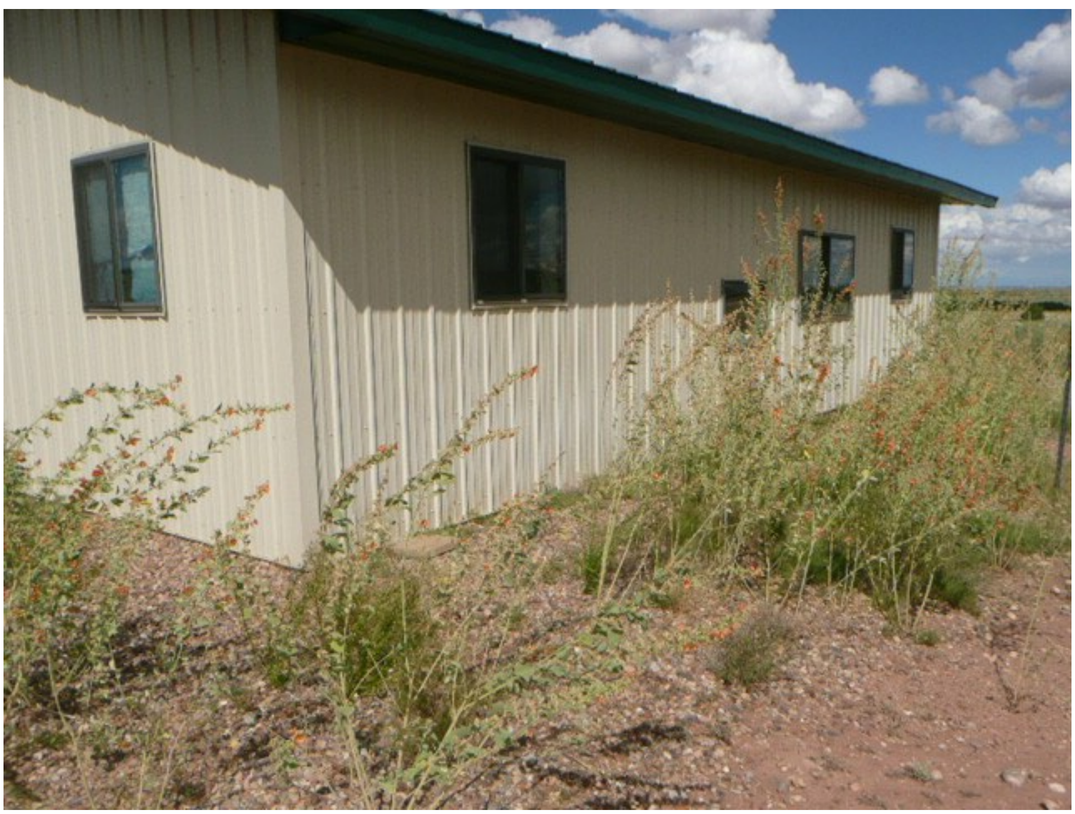
The table below shows the results and compares them with the outdoor baseline measurements.

	6 ft / 2 m	10 ft / 3.2 m	20 ft / 6.5 m
outdoors	1370	975	267
House-1	2263	1872	8256
House-2	3492	6979	3275
House-3	21,600	3164	2852

Table 1: Radiation levels from small microwave transmitter inside three metal houses, compared with outdoors. All numbers in uW/m^2.

Note how the radiation level rapidly diminishes with distance while outside. Inside the three houses, the radiation level is higher than outside and the distance to the transmitter had little effect on the radiation level. In some cases, the radiation level was higher at a greater distance to the transmitter.

The microwaves clearly bounce around the rooms and create local "hot spots." All the measurements were done well away from any walls to minimize local effects.



The outside of House-3, with steel siding, steel roof and metal-coated low-E windows.

In House-1, the strongest hot spot was 20 ft (6.5 m) from the transmitter, for no obvious reason.

In House-3, the transmitter was placed in a kitchen attached to a living room. The kitchen was only 10 ft (3 m) wide and gave powerful reflections when the instrument was just 6 ft (2 m) away, and much less once the instrument was out in the larger living room.

It is largely unpredictable where the hot spots will be, but it is safe to say that walking away from a transmitter inside a metal room is not a reliable strategy to limit exposure.

The bouncing does not continue forever. There is a little loss each time a radio wave is reflected, just as a mirror does not reflect light 100%. So, after several bounces the energy is used up. Once the source of the radio waves is turned off, the bouncing waves will be gone within a fraction of a second. They do not linger.

Using mobile phones, cordless phones, microwave ovens and wireless networks inside a metal house will clearly result in much higher exposures to radiation than outside or in a non-metallic house.

We do not expect smaller pieces of metal, such as nails or metal studs in an otherwise non-metallic house, to have an effect, but we have not tested that.

Does a metal house protect against radiation from outside sources?

Metal reflects radio waves. This means that the area behind a metal sheet will be shielded against the radio waves.

This author has many times noticed that the inside of a metal house has much lower radiation levels than outside — as long as there are no wireless transmitters inside. We also did some specific measurements.

In House-2, we tested how well the steel front door, the steel door frame and steel wall shielded an outside microwave transmitter. Doors are typically a weak part of a house shield.

We compared the radiation level with the door-and-wall providing shielding, to what it was out in the yard at the same distance.

	20 ft / 6.5 m
outdoors	267
metal wall & metal door	0.3

Table 2: Shielding of microwaves by metal wall, door and door frame, compared to no shielding (outdoors). Numbers in uW/m^2.

The wall and door provide a thousandfold (30 dB) shielding effect. It would have been less if the doorframe was not metal. If the door had been made of wood, there would not have been any real shielding.

We tested a bedroom window in House-3 in the same way. This window had an aluminum frame and the glass had a metal coating to reflect solar heat ("Low-E"). The results were:

	20 ft / 6.5 m
outdoors	383
window open	157
window closed	0.0 (ND)

Table 3: Shielding by metal wall, metal window frame and metal-coated glass. Numbers in uW/m^2.

Because the ground sloped down from the house, we were not able to raise the transmitter high enough so there was line-of-sight between the transmitter and instrument. This explains why the open-window scenario provided a little bit of shielding. Once the window was closed, the instrument was not able to pick up the transmitter at all.

Buildings made of brick or concrete rarely provide more than a tenfold (10 dB) reduction of microwaves. An example of a building with such non-metallic shielding is the MCS/EHS apartment building in Zurich, Switzerland, which provides just a five-fold (7 dB) shielding effect against microwave signals.

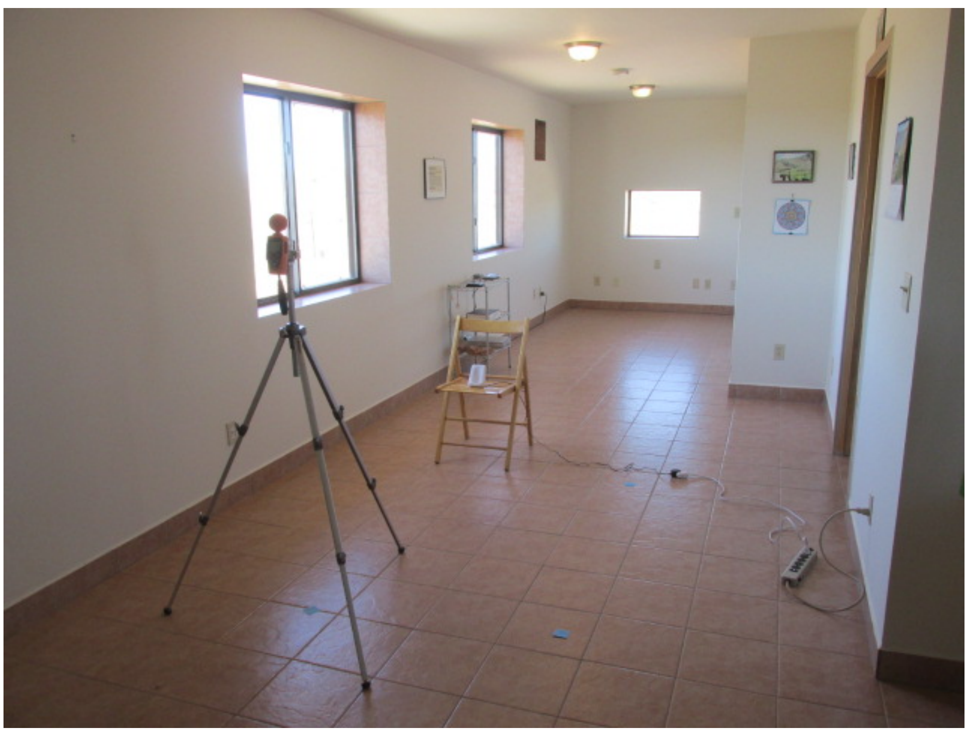
Is it possible to let bouncing radiowaves out?

As long as there are no transmitters inside a metal room, the radiation will be lower compared to a non-metal room. But what to do for people who own a metal house or work in a metal building, and who want the convenience of the wireless gadgets? Or other family members do?

Some people have suggested opening doors and windows to "let the radio waves out." Is this actually realistic?

We did our tests in House-2, which has a living room with three large (4 x 5 ft, 3 x 4 m) windows that do not have any low-E metal coating, so the sun's rays can enter to heat the house. These windows do not affect radio waves. In our test we compared the radiation in the room with the windows temporarily covered with aluminum foil, and without. We also tried to open the steel door that goes directly to the outside.

We did measurements in three different positions with distances of 6, 6 and 10 ft (2, 2 and 3 meters) to the microwave transmitter.



Testing inside House-2. The three big windows (two shown) have no metal-coated glass. The small window has metal low-E coated glass. The tripod is in position A.

	Pos A 6 ft / 2 m	Pos B 6 ft / 2 m	Pos C 10 ft / 3.2 m
outside	1370	1370	975
windows shielded door closed	1972	11816	5046
windows unshielded door closed	3132	3027	10369
windows unshielded door open	3713	3304	4005

Table 4: Shielded room with microwave source inside. With and without big holes in the shielding. Numbers are uW/m², average of three measurements.

The total area of the windows and the open door was about 70 sq ft (about 7.3 m^2) in an L-shaped room of 480 sq ft (50 m^2). Creating this big hole in the shield did not seem to have a clear positive effect. The readings were more affected by the repositioning of the tripod, which was done between each measurement. All three measurement positions were between the transmitter and the door. They were chosen as the more likely positions to show any effect from opening and closing the door. Position C was closest to the door (6 ft / 2 m) away) and the only position that showed a reduction in the radiation from opening the door. The reduction was only about 60%, the radiation level was still about four times what it would be in a non-metal house. Opening doors and windows clearly had little or no effect.

Will radiation from the outside bounce around inside?

What if some radiowaves come into a metal room from the outside, such as through a door or window that is open or unshielded?

We tested this by placing a transmitter 10 ft (3 m) outside a steel door, with the RF meter 10 ft inside the door (with line-of-sight).

	20 ft / 6.5 m
outdoors	267
door open	2164
door closed	0.3

Table 5: Microwave source outside, radiating through steel door, into metal room.

There was clearly a bouncing effect when the radiowaves entered the room through the open door. The inside radiation level was nearly ten times what it was outside.

We also did a test with an unshielded plain glass window in a metal room and line-of-sight between transmitter and instrument. The window was then covered with aluminum foil.

	20 ft / 6.5 m
outdoors	267
window not shielded	553
window shielded	0.3

Table 6: Microwave source radiation through window, into metal room of House-2.

The experiment we did in Table 3, with another window but not line-of-sight, did not produce an increased radiation level inside.

When a radiation source is very close, the radio waves can enter by many angles, which enhances the bouncing effect. This means that someone standing outside an unshielded window can still expose people inside to concentrated radiation from their portable wireless device.

The question is then what happens when the source is well away from the house, such as a neighbor's wireless network or a mobile phone base station?

Will radiation from distant sources bounce around inside a metal house?

House-2 is located in a remote rural area. A mobile phone base station is located about 10 miles (16 km) directly to the south and can be seen through the big south-facing windows. These windows are not shielded, while all the walls and the roof are covered in steel plates.

We did a test using two identical RF meters. One meter was placed inside the room with the three large unshielded windows, so the meter could directly "see" the tower (through the window). A steel door (pointing east) was also left fully open. The total opening was about 70 sq ft (7.3 m^2) for a 480 sq ft (50 m^2) room.

The second RF meter was placed on a tripod in the yard, 57 ft (18 meters) from the house to avoid reflections.

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We measured three time periods:

Period	Period 1	Period 2	Period 3
outside	9.1	10.8	11.8
inside	4.0	1.2	0.6

Table 7: Peak microwave levels for three ten-minute periods. Three large unshielded windows, plus open door. Numbers in uW/m^2.

The indoor reading was smaller than outside in each case. This is because the house still shields against radiation coming from other directions — sources that are further away or weaker, but they can add up.

A metal house, even with "holes" in the metal façade, is thus not a "trap" of microwave radiation from distant sources.

How we did the tests

We used the base from a cordless phone as microwave source, because it puts out a constant level of radiation and it transmits at a frequency (1.9 GHz) that is similar to those used by wireless networks and mobile phones.

The base was part of a Vtech DECT 6.0 cordless phone. Any DECT phone could be used.

A mobile phone was not used as it changes its radiation level depending on how well the reception from/to the nearest tower is. Measurements inside and outside the house, and even in different positions in the house, could not be compared to each other if a mobile phone was used.

The base had no battery, but was powered from an electrical outlet. This allowed the operator to turn the transmitter on and off remotely, using an outdoor breaker.

The RF meter was set to record the MAX (peak) radiation level. Then the operator left the room, turned on the transmitter for at least 15 seconds, turned it off and then went back into the room.

It is very difficult to measure in such a reflective environment. If the instrument is moved just a few inches, the result can be dramatically different. This is apparently caused by standing waves that can add (in phase) and subtract (out of phase). As an example, the following measurements were done in the same locations, but the tripod was moved between each measurement so the position changed by a few inches each time:

	#1	#2	#3	Avg
Pos A	1477	2075	2364	1972
Pos B	9927	13252	12268	11816
Pos C	1799	9351	3987	5046

The measurements were done using Tenmars TM-195 RF meters, which were always mounted on tripods with the antenna about 5 ft (1.5 meters) above the floor or ground. We verified that the two RF meters gave nearly identical readings when placed next to each other in the yard.

All measurements were done in the far field, which at 1.9 GHz is at least 1½ ft (0.5 m) from the transmitter. Like most RF meters, the TM-195 is not accurate inside the near field.

The mobile phone tower used for some measurements was the closest tower with line-of-sight and the only one to the south of the house. It held 4G transmitters, as did most towers in the region. A few older towers had 3G transmitters. The physically nearest tower was eight miles (13 km) away, but was shielded by a ridge. All other towers were 18 miles (28 km) or further away. The nearest neighbor was nearly a mile (1.6 km) away.

All measurements were done with line-of-sight to the transmitter, unless otherwise noted.

The outdoor ambient levels for all three houses were 10 uW/m^2 or less. The indoor ambient levels were much lower, due to the shielding effect of the three houses. In some cases, the instruments were unable to detect any ambient radiation inside the metal houses when their shields were fully in place.

The measurements were done on days with no thunderstorms in the region, as lightning could affect the peak measurements.

Metal sensitivity and stray electricity

A drawback to metal housing is that electricity can travel on the metallic surfaces if the electrical wiring is not done carefully. Such stray electricity can be detected with instruments that measure low frequency electric and magnetic fields.

Some people are sensitive to the metals themselves, even in houses located in remote areas without electricity.

More information

Articles about shielding rooms and houses, and various other technical reports, are available on www.eiwellspring.org.

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