Federal Pacific Electric

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Code Check

(last updated 11/28/2012)

A home inspector and mutual friend invited us to see a curious thing he had found during his inspection. A small fused switch in the basement was controlled by a 30-amp breaker in the basement subpanel, made by Federal Pacific Electric (FPE). When the inspector turned on the 30-amp FPE breaker, the fused switch started smoking. He then turned it back off. Ahead of this 30-amp Federal Pacific breaker was another Federal Pacific panel with a 100-amp main breaker and a 60-amp breaker feeding the basement subpanel.

The house was vacant and the breakers were all off. We weren't very well equipped. A small multimeter was our only tool for investigating possible shorts in the fused switch, and we didn't discover any abnormalities with the power off. We turned on the 30-amp subpanel breaker. We went upstairs to the service and turned on the 60-amp breaker, and then the 100-amp main…

Instantly, the entire wall holding the panel started shaking. There was a loud buzzing sound, and then an eerie whooshing sound overhead. Looking up we saw the individual overhead service conductors being whipped through the air, reacting violently to the high magnetic fields caused by carrying thousands of amps of current. I held my breath and reached for the main breaker. Fortunately, it did turn off the power.

That was the day I began to learn there was something to the stories I had been hearing about Federal Pacific Electric. We had a short circuit that drew so much current the service conductors were almost torn from the building. Three FPE breakers carrying this current each failed to respond to this short circuit.

Categorizing the Concerns

For years I had wondered whether the mere presence of an FPE panel warranted a recommendation for replacement. They were not without their defenders, and this particular brand was ubiquitous in some areas. There are millions of FPE panels in use, and they have UL labeling. How could they be as bad as the rumours we were hearing?

FPE was one of the most popular brands of equipment from the 1950's through the early 1980's, and didn't quit making breakers until 1986. Broadly speaking, FPE has three categories of problems:

1. They are old and built to lesser standards and codes than more modern panels.
2. They were poorly engineered, with many unique problems not found in other panels.
3. Many of their breakers are defective, and should not have been allowed on the market.

The last of these 3 issues is the gravest concern, since the record shows that the manufacturer knew their product did not meet UL standards and intentionally deceived the regulators to obtain their listing.

Older isn't Better

Several of FPE's problems are typical of other old panels. There is less wiring space, especially opposite main lugs and breakers, and the result is a crowded panel (figure 1). Over the years, the minimum wiring space required in codes and standards has increased. Significant changes occurred in the 1981 NEC, near the end of FPE's existence as a panel manufacturer, when the amount of space was increased for conductors needing to make more than one bend to exit the panel.

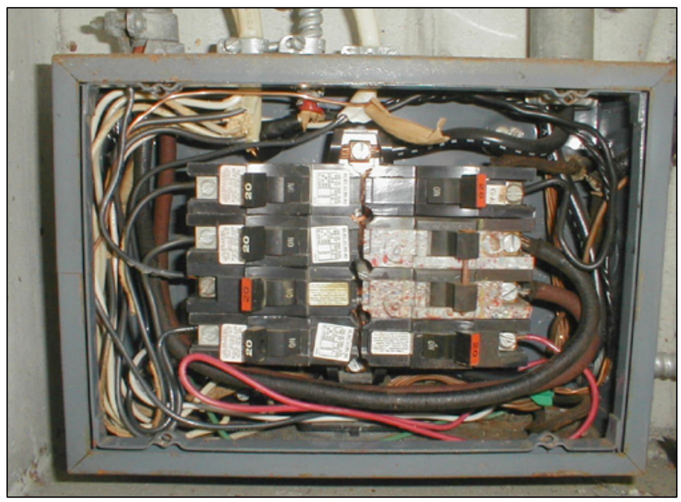

Figure 1 - Crowded FPE Panel

FPE sometimes installed their main lugs or main breaker terminals at an angle which enabled them to construct the panel with less wiring space. This method was no longer allowed after 1984 for conductors needing to make two bends in that wiring space.

The panelboard assemblies and bus bars on several of the FPE models were set on springs, with a depth adjustment that enabled the position of the breakers to be moved forward or backward. For a recessed panel, this feature allowed the breakers to be brought out flush to the deadfront cover even if the panel was (improperly) set too far back into the wall. The NEC has required rigid mounting for buses since 1981. The entire spring-loaded bus sometimes moves simply from operating a breaker handle. The breakers might also press against the deadfront cover, causing it to pop forward when its screws are removed. Larger FPE panels might have two of these adjustment screws.

Since the 1984 edition of the NEC, breakers that operate with their handles in a vertical position must be on when in the up position, and off in the down position. Prior to that time, several manufacturers made equipment such as that seen in figure 2, with a row of breakers that was on when down and off when up. The word "on" when upside down is "no."

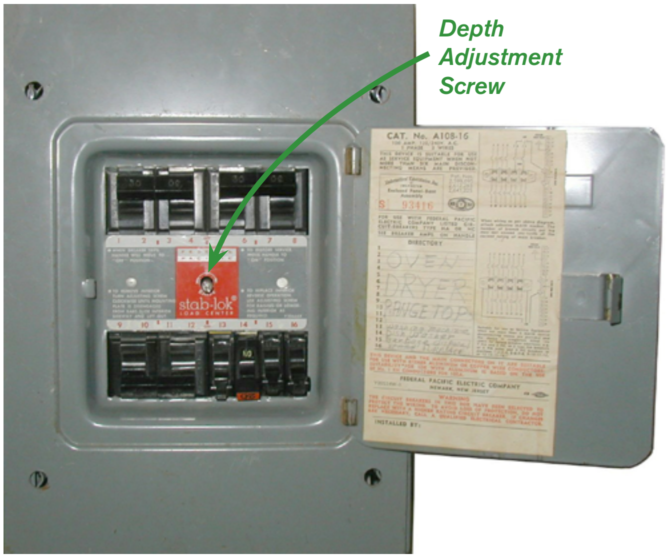

Figure 2 - 1960s FPE Panel

Inspectors might find that their first challenge with FPE is the difficulty in removing the deadfront cover without tripping the breakers. Several models of FPE panels have breakers that are on when the handle is positioned toward the outside of the panels (figure 2). The handles stick out slightly over the deadfront, past the twist-out opening for the breaker. To remove the cover, it is necessary to first lift it slightly away from the panel, then to slide it under the handles of one row while lifting the cover off the other row. Once the cover has cleared the other row, it has to be slid back under the handles of the first row, and then it can be removed. If an inspector pulls the cover straight off, some of the breakers will accidentally trip. The spring-loaded bus mounts sometimes cause this to happen as soon as the last screw is loosened.

Since 1971, breakers capable of interrupting a short circuit of 10,000 amps must be marked with their interrupting rating. Breakers without a marking are presumed to only be capable of interrupting a 5,000 amp short circuit or ground fault. Utilities attempt to limit the available short circuit current to residences to 10,000 amps. Breakers not marked with an interrupting rating might have contacts that melt or fuse together, or might have jamming of the mechanical tripping components at currents less than 10,000 amps.

Value Engineering – The Stablok Design

Most plug-in circuit breakers connect with spring-tension jaws that clasp over a bus bar. The FPE Stablok design is the opposite. The breakers have metal stabs that insert into a socket in the bus bar. The connection is between two pieces of metal at right angles to each other, only touching at their edges. The contact area between the breaker and bus is significantly less than with other brands, and this critical connection has higher resistance.

As with other manufacturers, FPE made full-width breakers as well as tandem breakers, where two breakers fit into the same physical space as one full size breaker. UL has a standard for a "Class CTL" panel that limits the number of breakers based on the overall panel rating. CTL stands for "circuit total limiting" and residential distribution panelboards needed to be listed to that standard. To obtain the UL listing as a Class CTL panel, the number of tandem breakers had to be limited to conform to the overall rating of the panel. FPE accomplished this by having an "F" shaped bus socket for full width breakers and an "E" shaped socket for tandem breakers.

A panel could have a combination of the two sockets and meet the UL standard as long as the maximum number of branch circuit breaker poles did not exceed the standard, which allows 20 breakers in a 100-amp panel, 24 for 125-amps, 30 for 150-amps, and 40 for 200-amps. If a panel was rated 150 amps it could have 10 "F" sockets (each capable of one breaker) and 10 "E" sockets (each capable of two breakers) for a total of 30 possible breaker poles.

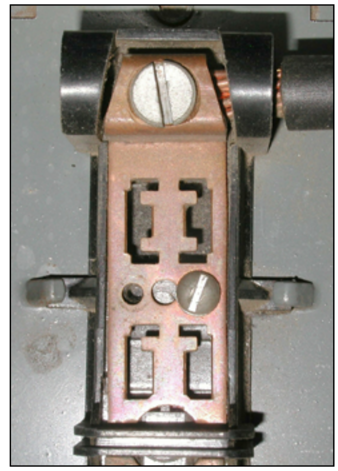

Figure 3 - E & F Sockets

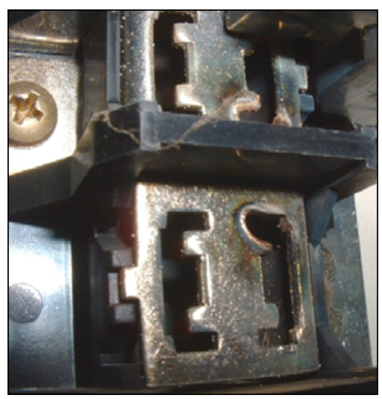

Figure 4 - Aluminum Sockets

Early FPE equipment had copper bus bars with the sockets cleanly defined (figure 3). Later FPE equipment used plated aluminum, which appears to have been stamped (figure 4). Some edges of the socket opening are slightly bent on these later models, further reducing the contact area of the breaker to bus connection.

Damage such as seen in figure 4 is quite common, though it cannot be seen until the breakers have been removed.

Fig. 5 - 2-pole E Breaker

Fig. 6 - 2-pole F Breaker

FPE breaker stabs were copper and formed with a bend to exert pressure on the edges of the bus socket. Pointed ends help guide the bus stab into the socket. The stabs on E breakers are remarkably fragile; and are easily damaged during installation. If the breaker has been pulled back out of the bus, the bus stabs become distorted and are often no longer parallel. The tension between the two stabs may be lost, and they do not securely snap into place. Loose breakers are a common problem with FPE. These loose connections overheat, and it is possible for arcing and damage to have taken place behind the breaker without visible damage to the front of the breaker. The damaged bus is not visible until the breakers are removed. The F bus stabs (figure 6) are more robust; the metal is more than twice as thick, and they are 3 times as wide as the E stabs (figures 5 & 7).

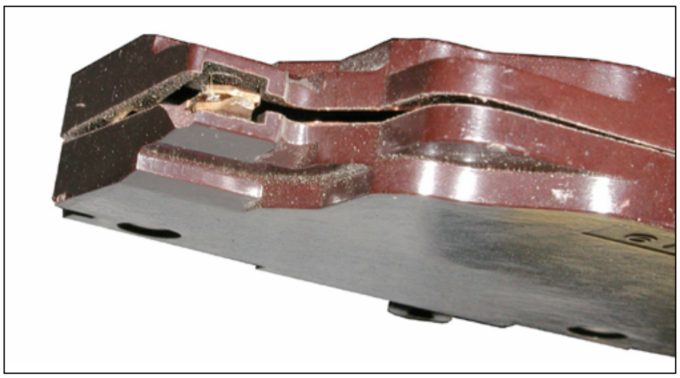

Fig. 7 - Receded Stab in Single-pole E Breaker

The F breaker stab is perpendicular to the direction the breaker handle operates, and the E stab is parallel to it. Note that an E bus slot will accept either an E or an F breaker, while an F slot will accept an F breaker or at most one E breaker.

However, by bending the stab an E breaker can be forced into an F slot (figure 8), though this will damage the breaker. The plastic case may split open and the bus stab can recede into the breaker, as in figure 7. Since it then has very loose contact to the bus, the breaker might fall out when the deadfront cover is removed. Inspectors can be forewarned of this condition before taking off the cover. Look at the panel label to see where the E slots are located and whether any E breakers have been inserted into F slots. When finding that situation, there is no need to remove the cover to know that the breaker is in the wrong position.

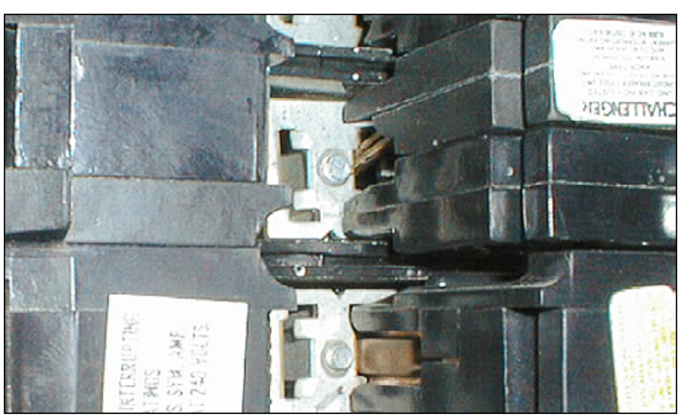

Fig. 8 - E Stab in F Socket

On some of the later models, individual bus sockets were mounted on riveted posts or on 8/32 screws. Cutler Hammer CH models and Square D QO models also have such methods for mounting an individual bus stab, though they only hold one breaker. An FPE bus socket could have as many as eight breakers on this relatively weak mounting. The mounting posts themselves become another point of high resistance and heat.

FPE also made split-bus panels. These functioned as service disconnects and load centers for branch circuits. The largest had room for up to six full-size 2-pole F style breakers. One of these breakers would feed the lower bus section which was to be used for lighting and appliance circuits.

As with many other brands, nothing prevented the installation of single-pole 120-volt breakers in the upper section that was intended for 240-volt breakers. Split-bus panels require that all of the breakers on the line-side bus be labeled as service disconnects in addition to labeling the specific use of the circuits.

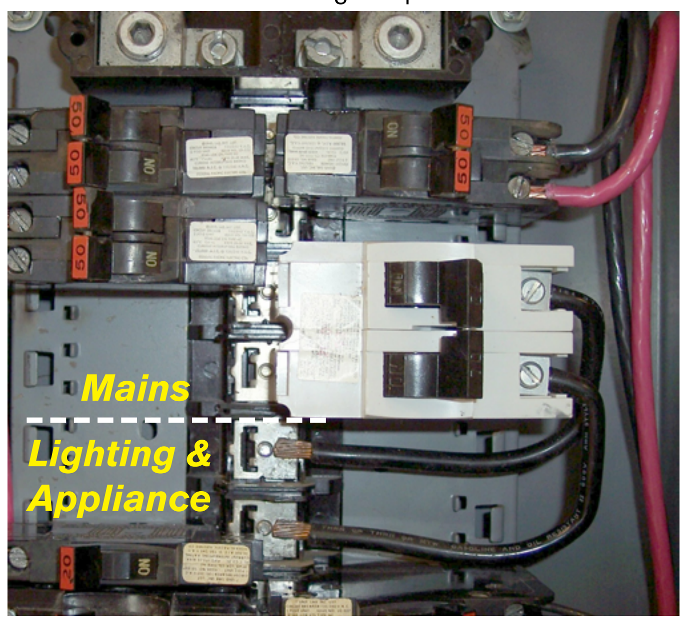

Fig. 9 - Split-Bus Panel

Where FPE differed from other split-bus panel manufacturers was in the method of connection to the lighting bus. On some FPE models the conductor from the upper breaker connected to a terminal, though on others it was simply soldered or brazed to the lower bus (figure 9). The NEC prohibits connections that rely solely upon solder [section 110.14(B)] yet allows connections made by brazing or welding. The heat necessary to connect these wires to the bus also can damage the plating on the bus, as in figure 9, and it is possible to install breakers on this same piece of damaged bus.

Looking for the Smoking Gun

Probably the most important of the “value engineering” decisions is the internal design of the breaker. Circuit breakers need to respond to overloads, short circuits, and ground faults. Breakers protect against overloads by the bending action of a bimetal that responds to heat and includes a trip lever that holds back the spring-loaded breaker armature. The bimetal is not intended to open the breaker quickly.

To trip quickly under the much higher currents of a short circuit or ground fault, a magnetic component is needed. In FPE breakers, it consists of a small block of ferrous metal connected from the heel end of the bimetal and parallel to it. High currents create a magnetic field on this "electromagnetic" block and exert a pulling force on the bimetal element , releasing the trip arm.

A spring is compressed when an FPE breaker handle is moved to the "on" position. That spring is the source of all the energy that will then operate the breaker mechanism when it needs to open. The series of mechanisms that must function for the breaker to open will remind older readers of the cartoons of Rube Goldberg. The copper armature must rotate on a shaft made of a steel coil spring, an arrangement that increases friction points and brings dissimilar metals in contact. Wires and rivets that act as shafts are in contact with dissimilar metals and molded plastics. The trip lever is activated by a "U" shaped piece of wire approximately the size of a staple that has one end in a plastic cam and the other end in the steel trip lever. The entire mechanical function of these breakers is only as good as the weakest link. The two-pole breaker in figure 10 has no fewer than 12 components that act as a shaft for a rotating part, and all 12 must move freely if the breaker is to operate.

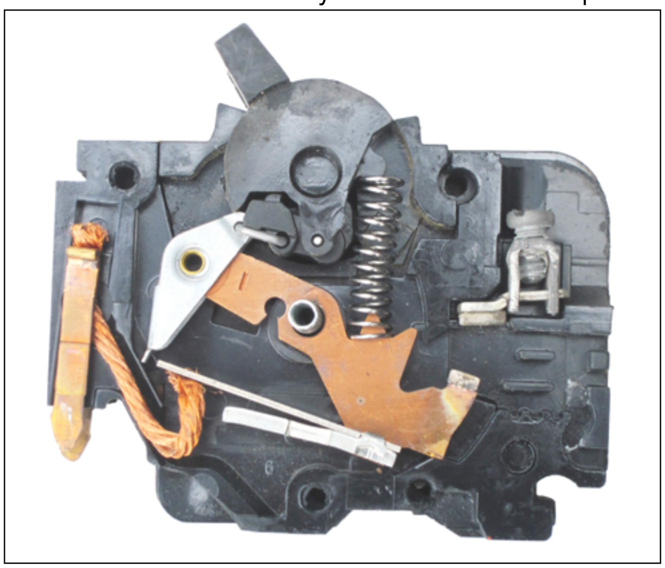

Fig. 10 - 2-pole E Stab Breaker

One cause of failure can be the routing of the internal fine-stranded conductor that connects between the breaker stab and the bimetal strip. Under high fault conditions, the bend in this wire will contract, and slightly improper routing of it can contribute to the breaker freezing in the closed position in response to high currents. In other cases, this conductor was allowed to contact the steel electromagnet block, which can impede its function.

Several of the breakers we opened had a cardboard insulating washer on a moving part. Others were rusted internally, even though the outside did not show any rust or corrosion. The main spring in some cases is stretched abnormally and could bind. The guide jaw on the spring in figure 10 is not present in some earlier breakers.

A clue to the problems with the FPE breakers can be found by looking at the subsequent breakers (figure 10) which did obtain listing by ETL after the initial FPE scandal. They improved them in several ways. Dissimilar metals are not in contact with each other, they used a solid shaft instead of a spring, and the wire connector was more robust. They also added a second spring to supplement the force of the primary spring.

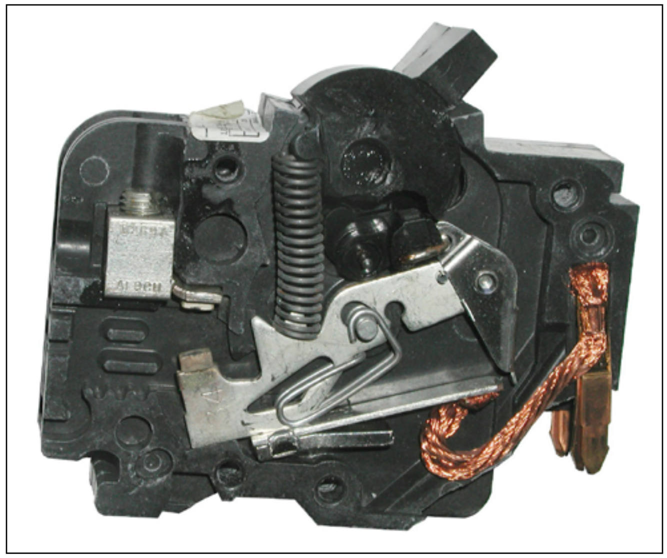

Fig. 11 - American brand 2-Pole Replacement Breaker

One thing all parties seemed to agree upon is that FPE did indeed use fraudulent means to obtain their UL listings. The question of how they did it is less important than what the actual failures are, and how they affect homeowner safety today. If the problem with FPE breakers were only in their ability to respond to dead shorts, there might be a relationship between the 1971 standardization of the required short circuit current rating and the incentive for FPE to deceive UL. However, that doesn't appear to be the case. Research sponsored by the CPSC found abnormally high failure rates for both overloads and high-current faults.

Curiously, FPE breakers have a higher failure rate after repeated handle operations. That finding runs contrary to the usual recommendation that breaker handles be exercised periodically to assure that internal parts do not freeze in place, and points to the mechanical design as the primary cause of the breaker failures. If a single aspect of the FPE design could explain their high failure rate, a solution might be possible. However, it seems to be a combination of multiple problems with both the bus and breaker design up until the early 1980's. During the period in question, various models of panels were made, some including the word "Stablok" and others without it. They all have this same problem.

Product Defect Litigation

Federal Pacific was acquired by Reliance Electric Company in 1979, and shortly thereafter Reliance was acquired by Exxon. In 1982 Reliance filed suit for $345 million against the liquidating trust that arranged the FPE sale because of liabilities accrued by the fact that "improper and deceptive practices were employed for many years to secure UL listings for Federal Pacific's circuit protective products." They stated that "as a result, most of the circuit protective products manufactured by Federal Pacific, at some point thereafter, lost their UL listing." Sales for these defective products were $100 million in 1979 alone. Reliance claimed that the deceptive practices ceased as of 1981 and that subsequent products met UL standards. They asked the Consumer Product Safety Commission (CPSC) to investigate, and also hired their own consultants. While CPSC did indeed find an abnormally high failure rate, especially on 2-pole FPE breakers, they also stated that a complete assessment of the problem would cost several million dollars, and their entire budget for that fiscal year was only $34 million.

Reliance claimed that their own testing contradicted CPSC's findings. Reliance blamed the poor results from the CPSC testing on operating them in a "repetitive, abusive manner that should not occur during residential use." They were referring to CPSC testing the breakers before and after repeated operations of the breaker handle (a test that is part of the UL standards). In other words, Reliance claimed that the breakers might work if you never snap them on and off. The results of Reliance's own testing have never been published.

Obviously a lot was at stake in the corporate re-shuffling of these companies. Reliance and Exxon divested themselves of FPE (and Federal Pioneer in Canada) during a worldwide slump in oil prices in 1986. Though lawsuits had been filed claiming hundreds of millions of dollars in damages due to manufacture of products that were deceptively listed and did not meet safety standards, consumers were not the intended beneficiaries of these suits.

In New Jersey, where FPE was headquartered, a suit on behalf of consumers was granted class action status. In 2002 a superior court judge issued a summary judgment affirming that FPE had knowingly violated the consumer fraud safety act of New Jersey, and a 2005 decision upheld the rights of the class for the suit. Unfortunately, it only applied to original owners of FPE within that state.

In 2008, another meeting took place at CPSC's offices, at which new test results were presented. These were of 470 breakers harvested since the original 1983 testing, and showed a failure rate of 23%

Defending FPE

Considering the high failure rate, why did CPSC fail to recall them in 1983? The issue arose at a time when the political climate was not favorable for CPSC to devote a huge percentage of their budget to the investigation. Reliance also sued the CPSC in an attempt to prevent publication of CPSC's research. Though CPSC prevailed on that issue, Reliance never allowed publication of the research they claimed contradicted CPSC's findings.

A 2-page letter in the May/June 1999 issue of ***IAIE News***, the magazine of the International Association of Electrical Inspectors, defended FPE breakers. The article claimed that all listings of FPE equipment were valid, and that home inspectors calling the equipment "hazardous" were making unsupported recommendations. The author of the article was identified only as the "former quality manager of FPE" and was otherwise anonymous. It claimed that the company still exists, and yet the only address provided for it was that of a law firm. (A company exists today under the name "Federal Pacific." It manufactures transformers, switches, and switchgear. It does not manufacture circuit breakers or panels, and never has done so. It is not the "Federal Pacific Electric" associated with the breakers and panels discussed here.)

As a member of IAEI, I was not alone in my feeling that the article was directly contradictory to the organization's mission statement. It served as a reminder that the assets and interests of FPE are part of larger and ongoing corporate interests, and they are not without their influence.

In December, 2007, the Kentucky Board of Home Inspectors issued an advisory bulletin stating that there is "no documentation from any source" that states FPE panels are a hazard, and that home inspectors making that claim can cause the homeowner undue financial hardship. Kentucky's home inspection regulations also prohibit home inspectors from stating, orally or in writing, whether or not any condition is a violation of building codes. There seem to be some interesting turf wars in Kentucky, and little official concern for the extent to which a fire might cause "undue financial hardship" to a homeowner.

With the combination of CPSC inaction, biased defenders, and bureaucratic inertia, it is small wonder home inspectors so often hear someone say that their FPE panel "has never caused us any problem." That statement illustrates the truth that few of them burn down the same house twice. Under normal conditions, a circuit breaker is never called upon to do its job. If you never overload a circuit, and never have a short circuit or ground fault, your electrical panel and breakers will not get much attention. You need it to work when something does go wrong. Even in the absence of an overload or short circuit, arcing can occur inside an FPE panel at the bus connection. They might cause a fire at the panel under normal loads without any other electrical hazard existing in the property. The very equipment that is supposed to protect you from fire can actually cause it.

Replacement Breakers

If the breakers themselves are such a problem, should homeowners consider replacing the breakers and keeping the panel? At various times over the last 2 decades, different manufacturers have made after-market products designed to fit FPE panels. In some cases, these breakers have been made in Canada, Mexico, or China. Salvaged old FPE breakers are also available from specialty dealers. For a time, Challenger manufactured FPE compatible breakers. Next was the "American" brand. Replacement breakers today are made by UBI. They cost from $50 to $90 each. By the time a homeowner replaced a panel full of old FPE breakers with these newer ones, they will have spent far more money than it would have cost to replace the equipment, and there still remain all the "value engineering" problems of the bus design. They will still not be able to find AFCI breakers, and would likely not meet the current applicable codes.

One of the most expensive aspects of replacing a flush-mounted (recessed into the wall) panel is cutting away the wall coverings to be able to remove and replace the enclosure. Replacement panelboards are available that can fit inside the existing enclosure, greatly reducing the cost of repairs, and these can be obtained with a UL listing. This won't work in all cases – sometimes the existing FPE panel is too small and complete replacement will be the only option.

The Inspector's Choices

Given this set of facts, what can inspectors say to their clients? In general, product defects and recalls are beyond the scope of a home inspection. Even if the CPSC were to request a recall of the product, such information would exceed the minimum standard of care for a home inspector. However, home inspectors who say nothing about it could find themselves with angry clients who wish that something had been said. If a purchaser calls an electrical contractor, and the contractor refuses to work on the system because it has an FPE panel, the clients will not be happy with their home inspection report. The product defect issue is becoming more widely known as a result of television and other media coverage in recent months.

10 years ago we wrote an article about FPE subtitled "Hazard or Hype" and attempted to dispassionately catalog the issues. Subsequent data, and the New Jersey Superior Court decision, have removed any doubt about the danger of Federal Pacific Electric residential breakers and panels. The verdict is in; they should be replaced.

Douglas Hansen is the lead author of the Code Check series of field guides to building codes, founded by Redwood Kardon. They are active electrical instructors and first met on the job site described in the beginning of this article.

We welcome feedback and additional contributions to this article. We encourage distribution of this article.

A Report from the Front Lines

My negative reaction to FPE panels is based on personal experience.

Experience #1: *In 1993, I inspected a house with an FPE panel. At that time I was completely unaware of any particular problems associated with this equipment. Six months later, I inspected the same house again because my original customer got transferred and had to move. At the 2nd inspection, I noticed the old panel was gone and a new panel was in its place. The owner explained that he was sitting at his table eating dinner one day when he looked up and his panel was on fire.*

Experience #2: *In 1996, I was inspecting a grimly run-down house, slithering through a 16" high crawlspace with water all over the ground. I had gone in a big circle around the perimeter of the crawlspace, and was almost out when I saw a piece of NM cable with two bare wires sticking out the end, dangling right across my path. There was no way through without danger of this cable reaching out and biting me. The only other way out was back the way I came. I figured, "Heck, I'll just touch the two wires to my pick. If they're dead, nothing will happen. If they're live, they'll short out and blow the breaker." So I touched them to my pick. The resulting explosion destroyed the pick. When I emerged, I headed straight for the panel. It was an FPE and none of the breakers had tripped.*

Experience #3: *In 1999 I was inspecting a house for a guy who owned it but was deciding whether to rehab it or bulldoze it. Halfway through the inspection, he decided on the bulldoze route. It had an FPE panel so we got into a discussion about them. 10 minutes later, we had set up a steel pipe next to the panel and made a pair of leads from some romex that we clipped off the wall. For the next 30 minutes, we tried shorting out one breaker after another on the pipe. Six out of the 10 breakers in the panel never tripped. With those breakers, we could make sparks and arcs and weld the wires to the pipe but the breakers stubbornly refused to trip.*

Experience #4: *In 2000 I was inspecting an apartment complex. The units were fitted with FPE panels. I asked the site manager about the panels and whether or not they had been problematic. He said that they were just fine and never caused a problem. About an hour later, he was paged - a fire had started in one of the units. Its electrical panel was in flames. My inspection lasted long enough that I was still there when the electrician was pulling away from the property after replacing the panel. When I finally left, the manager presented me with a gift - the burned up panel that the electrician had replaced. I still have it.*

- *The **only** time I've had a customer's panel catch fire, it was an FPE panel.*
- *The **only** time I've shorted out wires and had the breaker NOT trip, it was an FPE panel.*
- *The **only** time I've shorted out multiple wires and had 6 out of 10 breakers not trip, it was an FPE panel.*
- *The **only** time I've actually had a panel catch fire during one of my inspections, it was an FPE panel.*

There is something seriously wrong with this equipment. And while it's nice to have access to all this research, and New Jersey's court ruling, I don't need any of it. My personal experience is enough for me to advise my clients to get rid of these.

Jim Katen in Oregon