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HAZARDOUS FPE CIRCUIT BREAKERS AND PANELS

(Updated as of May 25, 2007)

Information for Inspectors and Homeowners

(Originally Prepared for the 17th Annual Spring Seminar, Feb. 21, 2004
St. Louis Chapter, American Society of Home Inspectors)

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PREFACE to the May 25, 2007 update

This document has been revised at this time for two major reasons. First, in a class-action lawsuit against FPE/Reliance in New Jersey, the Court found that Federal Pacific Electric Co. (FPE) committed fraud by representing that their FPE Stab-Lok® circuit breakers met the applicable (UL) standard test requirements when in fact they did not. The Court's finding of fraud, published in 2005, indicates that FPE cheated on the tests that were required to obtain and maintain UL listings. The company improperly applied UL labels to circuit breakers that could not and did not meet the UL requirements. FPE covered up the defective performance of the circuit breakers by a long-standing practice of fraudulent testing. The Court's finding helps resolve the question as to how the defective breakers got into the marketplace and into homes.

Secondly, the recent testing of FPE Stab-Lok® circuit breakers now includes breakers from 28 homes across the Country. The number of breakers tested is about double the number included in the tabulation of the original report. The results firmly support - to an even higher level of statistical certainty - the conclusion that virtually every FPE Stab-Lok® panel installed in homes today contains circuit breakers that are seriously defective, and that they should be replaced in the interest of electrical and fire safety.

Additional changes have been made in the report to enhance clarity and to add or update content. A section has been added that explains why the FPE Stab-Lok® breakers do not meet the fuctional requirements of the National Electrical Code or other applicable electrical safety codes and standards.

The author thanks all of those who have contributed to this electrical safety project.

Jesse Aronstein, Ph.D., P.E.

INTRODUCTION

The underlying reason for the presence of defective Federal Pacific Electric ("FPE") Stab-Lok® circuit breakers in millions of homes today is now publicly known, through a Court finding in a class action lawsuit in New Jersey. For a long time, while this line of circuit breakers and panels were in production, FPE cheated on its testing to cover up the fact that the product did not reliably meet the applicable UL (Underwriters Laboratories, Inc.) safety standard requirements. Because of the cheating, defective product got into the market, past the normal electrical safety system of checks and balances. Having obtained and maintained its UL listings by fraudulent testing, FPE applied UL labels to the product by which they (the manufacturer - FPE) falsely certified that the breakers met the UL requirements. Without the fraudulent application of the UL labels, the defective breakers could not have been marketed, installed in millions of homes, and approved by electrical inspectors. Although the company ceased manufacturing these breakers in the mid-1980's, their defective circuit breakers remain today in millions of homes, presenting an increased risk of fire and injury.

Supposing the circuits in your home were fed by a fuse box, with screw-in fuses. You may have seen these in some homes. You may also know about the unsafe practices of over-fusing (installing a higher-amperage fuse than appropriate for the circuit wiring) or putting a penny in the socket behind the fuse itself -- actions taken to deal with the "nuisance" of fuses frequently blowing on overloaded circuits, or to deal with the lack of a spare fuse. Now, let's assume that an inspector notes some over-fusing and pennies behind some fuses, and waves the warning flag that it is a hazardous condition - a “safety defect”. Inspectors, electrical contractors, fire prevention professionals, and real estate agents would agree that these conditions are hazardous (increasing the risk of fire and injury), that the homeowner should be alerted, and that the unsafe condition should be corrected immediately. Red-flagging the Federal Pacific Electric (“FPE”) Stab-Lok® panel and its breakers is essentially the identical warning; it is the equivalent of having more than 1/3 of the circuits over-fused and/or with pennies behind the fuses.

Failure to trip properly under overload and/or short circuit is the basic safety defect of the FPE breakers. For example, if an overload or short circuit occurs in the clothes dryer or the circuit feeding it, the breaker is expected to trip open to minimize the resulting fire hazard. But, if it is an FPE Stab-Lok® two-pole breaker, extensive testing (by FPE, CPSC, UL, and others) has demonstrated that it cannot be depended on to trip properly. A substantial portion of the FPE two-pole Stab-Lok® breakers, the type that would feed the dryer circuit, fail to operate properly. A significant portion of them jam and will not trip at all, no matter what overload current is applied. Additionally, there are problems with the FPE Stab-Lok® single-pole breakers and combination breaker/GFI units.

The circuit breaker defects become important if and when there is a short circuit or substantial overload in the downstream circuit. Most breakers in a home are never called upon to trip, and the homeowner's perception is that "the breakers work fine". The same observation could generally be made if there were no breakers (or fuses) at all in the electrical system. In the event of an electrical malfunction, however, our safety may depend on proper operation of the circuit breakers.

In my own home, only two of the breakers have ever tripped during more than a quarter-century of our occupancy. I know nothing about the ability of any of the others to function properly, except that they are a brand and type that has not been identified as having any significant performance problems. There is no data suggesting that I should be concerned about their ability to function properly. With FPE breakers, however, there is a substantial body of test data and other information available that demonstrates a serious problem.

Safety problems also exist in the FPE panelboards (panels) in which the breakers are installed. Some of the most common FPE Stab-Lok® panels are failure-prone due to marginal interconnections between the current-carrying components. The failing interconnections overheat at high current loading, and, in the worst case, fire ignites within the panel.[1]

Details regarding both the FPE Stab-Lok® circuit breaker and FPE panel performance problems are provided in the following sections. The bottom line is this: based on the information that is available and the testing that has been performed, there is no question but that homeowners need to be alerted to this safety defect and advised to have it corrected. Unless the occupants are informed and willing to live with the risk posed by defective circuit breakers, the FPE Stab-Lok® panels should be replaced.

<u>FIGURE 1</u> - REPRESENTATIVE SAMPLES OF HALF- AND FULL-WIDTH FPE STAB-LOK® CIRCUIT BREAKERS ***(left to right: 1/2-width double pole, full-width double pole, 1/2-width single-pole, full width single-pole)***
Note that the color and style of the handle varied over the years.

1. FPE STAB-LOK® BREAKERS DO NOT MEET CODE REQUIREMENTS

With regard to the electrical system in buildings, all applicable building codes and standards require operational and properly sized (current rating) circuit protection. This is normally accomplished by the installation of either circuit breakers or fuses. Because of their high defect rate, the FPE Stab-lok® circuit breakers do not meet the functional requirements of the electrical safety codes and standards.

The general requirements for installation of circuit breakers or fuses in buildings are in the National Electrical Code ("NEC"), which is a so-called "model code" that is generally adopted all or in part by State and local jurisdictions. The NEC is maintained and periodically updated by a process that is administered by the National Fire Protection Association (NFPA), which also publishes the actual text document. The NFPA does no testing of the components of the electrical system, nor does it approve (or "certify", or "label", or "list") specific brands of electrical equipment as suitable for use under the requirements of the NEC.

Detailed performance requirements for residential circuit breakers are embodied in Underwriters Laboratories' Standard UL489. That standard has served for many years to define the boundaries between acceptable and unacceptable circuit breaker performance. Conformance to the standard is generally indicated by a UL "label", which is applied to each breaker by the manufacturer as its (the manufacturer's) certification that the breaker meets the requirements of UL489. UL allows the manufacturer to do that, after "listing" it (having tested and accepted initial samples) and establishing a periodic inspection and sample testing program (by UL, in addition to the manufacturer's own production line and quality control testing) for that product. UL is paid by the manufacturer for the listing, labeling, and follow-up services. The manufacturer is UL's client. For the FPE Stab-Lok® circuit breakers, UL listing and periodic follow-up testing was actually done by FPE personnel at FPE's facilities, monitored by a UL inspector. UL did not itself independently test the FPE breakers for the listing or "follow-up services" program. UL claimed to be unaware of FPE's fraudulent testing practices.[6]

Facilitated by its fraudulent testing, FPE produced defective Stab-lok® breakers for many years. They falsely applied the UL labels as their certification that they met the applicable UL standard. Without the UL label on them, the breakers could not have been sold, as electrical inspectors would not accept an installation without (UL) labeled equipment. To the inspectors, the label (and UL "listing") is taken as evidence that the product is "suitable for the purpose" under the provisions of the NEC. In the case of FPE's Stab-lok® circuit breakers, however, it was not true.

On the basis of all available test results, it is clear that the FPE Stab-Lok® circuit breakers do not meet the functional requirements of the NEC, State and local codes, or UL489. Nevertheless, some people in the trade (inspectors, engineers, electricians, electrical contractors, and power company technicians) may claim that the FPE Stab-Lok® breakers are in conformance with applicable code(s) because they are (or were at the time of installation) UL "listed and labeled", without regard for the actual functionality. Such statements really say that the electrical distributor did nothing wrong by stocking the product for sale, the electricians and contractors did nothing wrong by installing them, and the electrical inspectors did nothing wrong by approving the initial installation. They are not at fault in that regard. FPE's fraud duped them all, and UL as well.

From an electrical safety standpoint, the fraud has left homeowners and occupants with an increased risk of fire and injury. The defective performance of the FPE Stab-Lok® breakers is not in actual compliance with the NEC or any other electrical safety code.

2. FPE STAB-LOK® CIRCUIT BREAKER TEST RESULTS

Tests of FPE Stab-Lok® circuit breakers were conducted by at least four companies and one federal government agency in about the 1979 to 1983 period. These included FPE (and its parent company, Reliance Electric), Southwest Research Incorporated, UL (Underwriters Laboratories, Inc.), CPSC (U.S. Consumer product Safety Commission), and Wright-Malta Corp. (for CPSC). Only the CPSC/Wright-Malta test results were ever made public.[1,2,3,4] Test results obtained by the others have been shielded from the public by proprietary and confidentiality agreements. While their actual test results remain hidden from view, there is no indication that their test results differ significantly from those obtained by CPSC.

Recently, additional tests have been conducted on FPE Stab-Lok® breakers from homes across the country. The sample size, presently approaching 500 circuit breakers, makes this the largest body of publicly-available test data on the FPE Stab-Lok® circuit breakers. The results are consistent with the test results obtained in about 1980. These new test results clearly demonstrate that the serious defects revealed by tests more than 25 years ago are present today in the FPE Stab-Lok® breakers installed in homes.

A summary of available results for tests on FPE Stab-Lok® circuit breakers is provided in Table 1, below. Additional information on the testing performed by the various parties are discussed in the sections immediately following.

Tests on FPE Stab-Lok® Circuit Breakers	**Number of Breakers Tested**	**No Trip Failures @135% of Rated Current***	**Number of Critical Safety Failures****
CPSC			
Single-Pole	14	4 (28%)	1 (7%)
Double-Pole	27	20 (74%)	5 (19%)
Wright-Malta Corp. (for CPSC)			
Double Pole	122	62 (51%)	12 (10%)
Independent (J.Aronstein)			
Single-Pole	345	61 (18%)	4 (1%)
Single-Pole GFI/Breaker ***	5	3 (60%)	4 (80%)
Double Pole	120	42 (35%)	14 (12%)

** UL test requirement. Includes samples that are also critical safety failures*
*** Failed to trip @200% of rated current, or jammed.*
**** For the combination GFI/Breaker the number includes critical failure of breaker and/or GFI function.*

TABLE 1 - SUMMARY OF TEST RESULTS ON FPE STAB-LOK® CIRCUIT BREAKERS

A. <u>CPSC Tests</u> In the 1980 time frame the U.S. Consumer Product Safety Commission (CPSC) investigated the performance of circuit breakers. CPSC performed its own laboratory tests on samples of FPE Stab-Lok® single-pole and double-pole breakers. For these samples, they found that 85% of the double-pole breakers and 39% of the single-pole breakers failed one or more of the UL test criteria. The double-pole breakers that failed to trip at 200% of rated current were considered to be "critical" (safety) failures. This term was adopted for failures to trip at 200% of rated current (and above), and it was based on CPSC-sponsored analysis and testing at the U.S. National Bureau of Standards (NBS, now NIST). The NBS tests demonstrated 200% of rated current to be the threshold of fire ignition hazard for residential wiring in an insulated wall.

Additional tests on 122 two-pole FPE Stab-Lok® breakers in ratings from 30 Amp to 80 Amp were conducted for CPSC by Wright-Malta Corp. These breakers were tested according to the Underwriters Laboratories' (UL) criteria for operation at 135% and 200% of rated current. [2, 3, 4] The breakers should trip (open the circuit) at these currents within a specified time, with the current applied to either one pole or both poles. (The FPE Stab-Lok® two-pole breakers in ratings below 90 amp are essentially two single-pole breakers ganged together with linked handles, and they may or may not have an internal "common trip" mechanism, which is intended to assure that tripping of one pole causes both poles to open. Older FPE Stab-Lok® two-pole breakers do not have this feature.)

For the Wright-Malta tests at 135% of rated current, 51% of the double-pole breakers failed with individual poles tested, and the failure rate was 25% with both poles tested simultaneously. The failure rates increased to 65% and 36%, respectively, after 500 operations of the on/off toggle handle (a shortened version of the UL mechanical endurance test).

For the test at 200% of rated current, the failure rate was 1% on individual poles tested, and 0% with both poles tested simultaneously. The failure rates increased to 10% and 1%, respectively, after 500 operations of the on/off toggle handle.

From an electrical safety standpoint, the most significant hazard identified in these CPSC-sponsored tests is that many of the two-pole FPE Stab-Lok® breakers may jam when trying to trip from overcurrent on one pole. This is due to mechanical friction in the common trip mechanism. Once the circuit breaker jams, its contacts will remain closed no matter what the current loading. This is serious -- it is a total failure that disables the protective device for that circuit. Essentially, the jammed breaker is exactly analogous to the "penny behind the fuse". This type of failure occurred in about 10% of the two-pole breakers in the test program.

FPE claimed that the jamming was a consequence of the test conditions (toggle operations) and would not occur in actual use. Subsequent testing of samples from homes has disproved that claim. (See Section 2E, below.) The friction changes in the mechanism that causes the jamming occurs in long-term use under normal conditions in homes, not only by repeated on/off toggle operations in the tests.

The balance of the overcurrent failures are similar to "overfusing". For instance, a 30-amp breaker, which is normally expected to trip somewhere above 30 amps and below 40.5 amps (the UL 135% test point), actually doesn't trip until 44 amps. The 30-amp breaker is essentially a 40-amp breaker. This is analogous to the condition of "overfusing", a practice that is universally considered to be unsafe even though it is not as dangerous as a totally jammed breaker (or penny behind the fuse).

B. FPE Test Results Federal Pacific Electric and/or their parent company Reliance Electric investigated their own circuit breakers and notified CPSC of problems associated with their full-width two-pole Stab-Lok® residential breakers.[5] They have never made public any test data or technical reports on the 2-pole or any other breakers in their line. Recently, a homeowner called FPE and was told that FPE had performed the same tests (as CPSC), but no details regarding the test results were provided. When the homeowner asked for written reports of the test results, they (FPE) said that they did not have them.

C. Southwest Research Incorporated performed testing under contract to FPE/Challenger regarding the performance of the FPE full-width two-pole residential Stab-Lok® breakers and some of the potential hazards resulting from overcurrent conditions.[5, 6] Their reports have not been made public. Lacking any information or claims to the contrary, it is reasonable to conclude that the results of their functional tests on the two-pole breakers were consistent with the findings of FPE/Reliance, CPSC, and Wright-Malta as to the defective performance.

D. Underwriters Laboratories Inc. has never made public any of its test data on FPE breakers. It is important to note that UL itself did not actually perform compliance testing on the breakers being manufactured by FPE over the years. Instead, UL's follow-up services inspectors were responsible for monitoring the production and the testing being done by FPE at the factory. This is where a major part of the fraud occurred, and UL was apparently not aware of it for many years. When the FPE Stab-Lok® problems surfaced, in part as a result of the CPSC investigation, UL performed some tests of its own. No UL report of that work has ever been made public. As with the Southwest Research work, lacking any information or claims to the contrary, it is reasonable to assume that the results of UL's special testing project at that time were consistent with the findings of FPE/Reliance, CPSC, and Wright-Malta as to the defective performance.

E. Recent Testing of Field Samples Over the past several years, I have acquired 28 FPE residential panels complete with their circuit breakers from homeowners in various parts of the United States who have had them replaced. Table 1, below, presents a summary of the test results to date (5/25/07) for the FPE Stab-Lok® breakers from the 28 field sample panels.

Type of Breaker	Tested	No-Trip Failures @135% of rated current *	Jammed
FPE Single-Pole, 1/2 Width	268	55 (21%)	3 (1%)
FPE Single-Pole, Full Width	77	6 (8%)	1 (1%)
FPE Single-Pole, GFI/Breaker**	5	3 (60%)	2 (40%)
FPE Double Pole, 1/2 Width***	39	13 (33%)	7 (18%)
FPE Double Pole, Full Width***	81	29 (35%)	7 (9%)

** includes those that jammed (did not trip at any overcurrent level tested).*

*** Circuit breaker function. Three of the combined GFI/Breaker units tested also failed when tested for GFI function*

**** 2-pole breakers tested on individual pole overload*

TABLE 2 - SUMMARY OF RECENT TEST RESULTS ON FPE STAB-LOK® CIRCUIT BREAKERS FROM 28 HOMES (results as of 5/25/07)

Those listed as "jammed" did not trip at any overcurrent level tested, and the jamming was confirmed in most instances by X-Ray inspection of the mechanism, which showed the trip lever released but the electrical contact points still closed.

These recent tests provide performance data for the single-pole FPE Stab-Lok® breakers, both 1/2-width and full-width, and for the 1/2-width double-pole breakers. FPE and others often state or imply that the only known problem within the FPE Stab-Lok® circuit breaker line is with the full-width double-pole breakers that FPE/Reliance called to CPSC's attention. That is not true, however. The recent test results, along with CPSC's own testing, clearly show substantial defect rates across the entire FPE Stab-Lok® residential circuit breaker product line.

The double-pole FPE Stab-Lok® breakers have a much higher rate of jamming (failure to trip at any current) than the single-pole. This reflects the fact that the major cause of the jamming of the double-pole breakers is friction in the "common trip" mechanism. This mechanism does not exist in the single-pole breakers.

The recent testing has also provided data on the 1/2-width FPE Stab-Lok® double-pole breakers, which had not been previously available. The data shows no significant difference between the 1/2-width and full-width double pole breakers; both types exhibit both calibration and jamming failures.

The results of the recent testing clearly demonstrate that the circuit breaker problems are not restricted to the full-width two-pole breakers that were the primary focus of the CPSC investigation. The problems extend across the full Stab-Lok® residential circuit breaker line, including the combined breaker/GFI.

3. FPE STAB-LOK® COMBINATION BREAKER/GFI

Five FPE Stab-Lok® breaker/GFI units were among the field samples tested. Four of them failed. This is not suprising, since the breaker/GFI design is based on the 1/2-width two-pole breaker, which is prone to jamming due to the common-trip mechanism. The single-pole breaker/GFI is essentially a double-pole breaker with one side actuated by a special circuit that reacts to a small (5 milliamp) difference in current between the line and neutral conductors passing through it. When the common trip mechanism causes a jam, it defeats both the circuit breaker and GFI functions. Two of the five units tested jammed. While the sample size is not large, it is nevertheless significant because it was a truly random sample. The five units tested were from different panels in different parts of the country.

A previous sample can be added: a field failure in which an FPE Stab-Lok® breaker/GFI "protected" a lighting circuit in which a short circuit occurred between a switch and its grounded metal (brass) cover plate. The event, which resulted in a serious injury, formed a relatively large globule of melted brass at the point of arcing to the grounded coverplate. The melting could not have happened if the GFI function had operated properly, as that would have limited the current to a level well below one amp. That FPE Stab-Lok® breaker/GFI was subsequently tested and was confirmed to be defective. Altogether, including this previous sample, I have crossed paths with six FPE Stab-Lok® breaker/GFI units, five of which were defective.

4. NON-FPE STAB-LOK® BREAKERS

Since the end of manufacturing of circuit breakers under the Federal Pacific Electric (FPE) brand, compatible Stab-Lok® type breakers have appeared under names such as "American", "Federal Pioneer", "Challenger", "Federal Pacific Reliance Electric", UBI, and "Federal Pioneer Limited" (Canada). There is insufficient data (too few samples tested) at this time on which to base an accurate judgment as to their reliability relative to the FPE breakers. In many instances, these are essentially the same product as FPE. Whether or not any substantive changes in design or manufacturing were made to solve the known problems associated with the original FPE Stab-Lok® breakers has not been determined. A summary of the test results on the non-FPE breakers that were included in the panels from 28 homes (Section 2E, above) is shown in Table 3.

Brand of Stab-Lok® Breaker	Tested	No-Trip Failures @135% of rated current *	Jammed
American FPE			
Single-Pole	18	6	1
Double Pole **	7	2	1
Challenger			
Single-Pole	5	0	0
Double Pole **	2	0	0
UBI			
Single-Pole	2	0	0
Double Pole **	3	0	0
Reliance			
Single-Pole	0	0	0
Double Pole **	1	0	0
Federal Pioneer (Canada)			
Single-Pole	3	0	0
Double Pole **	1	1	1

** includes those that jammed (did not trip at any overcurrent level tested).*

*** 2-pole breakers tested on individual pole overload*

TABLE 3 - SUMMARY OF RECENT TEST RESULTS ON NON-FPE STAB-LOK® TYPE CIRCUIT BREAKERS (From same panels as Table 2 breakers, results as of 5/25/07)

5. FPE MAIN BREAKERS

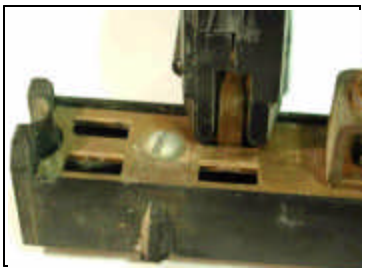
Although there have been incident reports in which FPE main breakers have failed to trip under circumstances in which people thought they should have, there is very little test data available on which to base any conclusion - one way or the other - as to the reliability of the main breakers utilized in FPE Stab-Lok® residential panels. *(It is also important to note that FPE panels in many homes do not have a main circuit breaker. See section 7.)*

Ten FPE 90 and 100 Amp two-pole main breakers (Figure 6) are included in the results presented in Table 2. Four of the ten failed to trip at 135% of rated current as required.

6. FPE STAB-LOK® PANELS

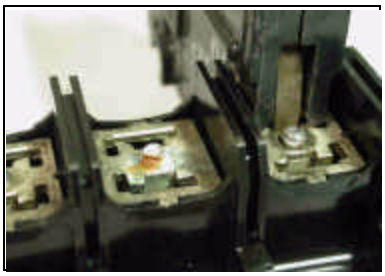
Even if it were possible to replace all of the suspect FPE Stab-Lok® breakers with a more trustworthy type, that would not correct hazardous internal failure modes intrinsic to many of the FPE panels. Seven of the twenty eight FPE Stab-Lok® panels in the present study showed evidence of internal overheating due to this type of failure. The overheating ranged from mild to severe in these failing panels.

The "panel" is the unit within the enclosure, on which the breakers are mounted. The main electrical service feeders (electrically live, from the meter) are connected at the panel, and the panel has an internal conductor system that distributes the power to the individual circuit breakers. The internal conductor system consists essentially of "bussbars" (thick metal bars) that have sockets incorporated or attached, into which to which the breakers' "stab" contacts are inserted. There are many different types of bussbar constructions in FPE panels, three of which are shown in Figure 2.



A. Copper buss bar with punched openings.

B. "Z" clip, clamped to . bussbar with 10-32 screw.



C. Stab socket on a post, attached with an 8-32 steel screw.

FIGURE 2 - THREE DIFFERENT FPE STAB-LOK® SOCKET DESIGNS

Of the three types illustrated, the one shown in Figure 2-C is known to have a high probability of deteriorating and overheating of the stab socket structures when subjected to significant current flow. Each individual stab socket plate is connected to its bussbar via a post (spacer), and the assembly is held together by an 8-32 steel screw. FPE panels with this construction are prone to overheating failure. The seven panels of the present study that showed evidence of serious overheating were constructed this way. One example is shown in Figure 3.

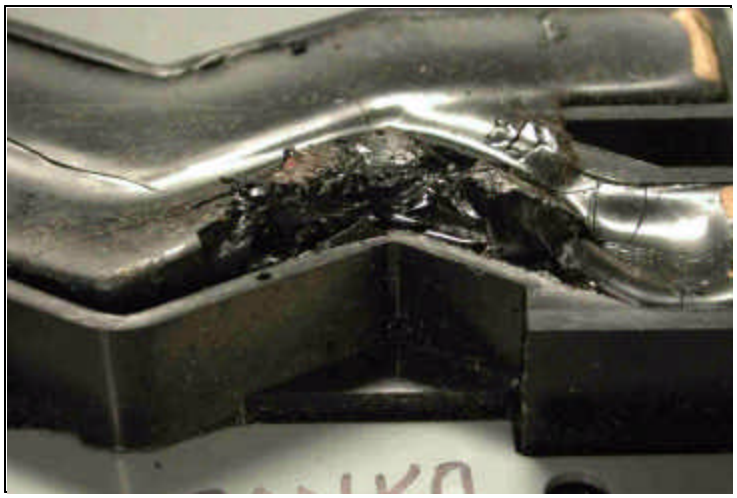
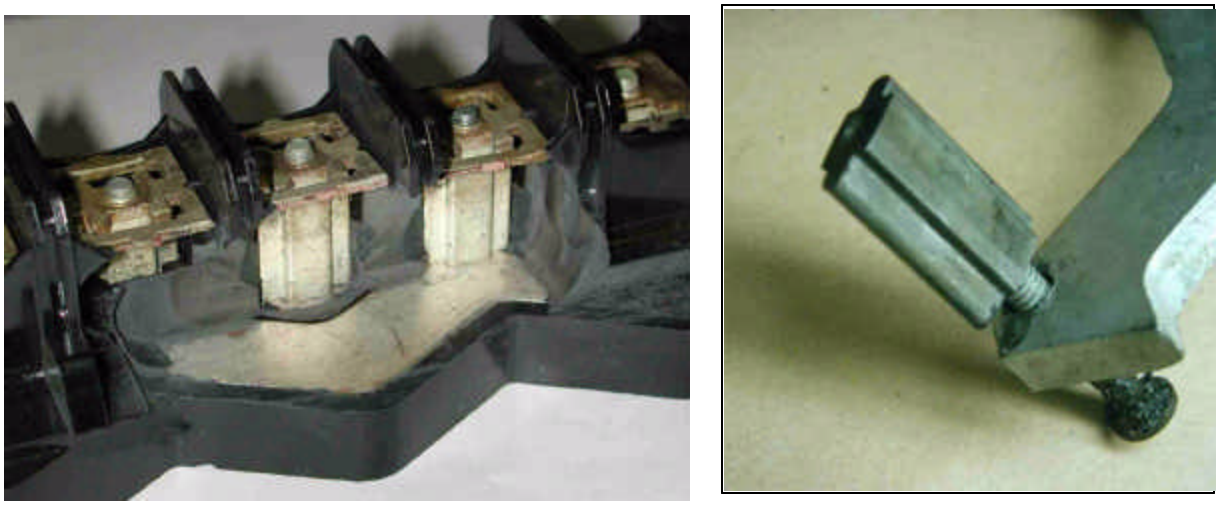


FIGURE 3 - OVERHEATING AT THE CONTACT BETWEEN THE BUSSBAR AND THE STAB SOCKET ASSEMBLY CAUSED THIS DAMAGE TO THE INSULATION.
(This view is of the backside of the panel. The damage could not be seen unless the panel is taken out of the enclosure.)

A more serious failure of this type has been documented.[1] In that instance, the failure had been severe enough to ignite a smoldering fire on the plastic insulating material. The fundamental weakness in this design is the use of a single, relatively flimsy 8-32 screw to hold a structure together that can feed up to four half-width breakers with a total "ampacity" (rated circuit capacity) up to about 160 Amps. Figure 4 shows how the stab socket plate and post are attached to the bussbar.

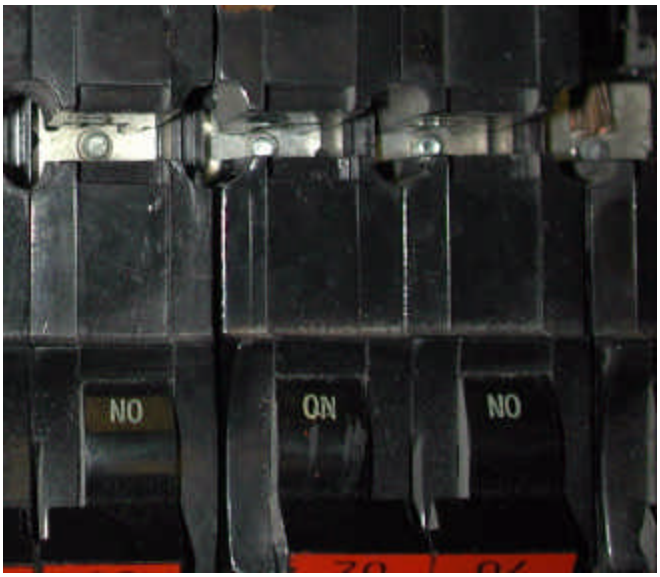


A. Cutaway - Bussbar, Post, and Stab Socket Plate. **B. Bussbar, Screw, and Post**

FIGURE 4 - CONDUCTING PATH FROM BUSSBAR TO STAB SOCKET

Various material combinations were utilized by FPE in these assemblies. Some bussbars are copper, others are aluminum. Some posts are copper, others are aluminum. The worst case (most likely to fail) is where both the bussbar and the post are made of aluminum, and the best case (least likely to fail) is where both are made of copper. Inspectors (or homeowners, or electricians) have no way of knowing which materials are utilized in any particular FPE panel with this type of construction.

Inspectors can, however, determine if a particular FPE panel has this type of construction, and, to a limited extent, whether it has failing bussbar interconnections that have previously overheated. With the panel cover off, for this type of panel, you can see the ends of the screws holding the stab socket plate as shown in Figure 5. (Note: If you see slotted screwheads, that's a different type of panel construction.) The stab socket plates and the visible ends of the screws should have a bright metallic look. Darkening, discoloration, or signs of corrosion most likely indicate past episodes of abnormal overheating.



<u>FIGURE 5</u> - THE ENDS OF THE SCREWS HOLDING THE STAB SOCKET PLATES ARE VISIBLE BETWEEN THE TWO ROWS OF BREAKERS. THIS IDENTIFIES IT AS A PANEL OF THE TYPE SHOWN IN FIGURE 2-C

Some FPE Stab-Lok® panels have 100-amp main breakers that feed into the bussbars through the same plate and post system. In this design, the two main breaker output terminals do not have the stab type contact. Instead, each one is screwed down to a plate the same size as the stab socket plate, but which has a threaded hole in it instead of the stab openings. As with the plate and post assembly, the screws clamping the main breaker terminals are size 8-32, which is absurdly small for clamping the terminals of a 100-amp main breaker.

To put the diameter of the 8-32 screw in perspective, it is the same size as used on common receptacles for connecting #14 or #12 copper wire (for 15- and 20-amp circuits), and has a diameter of only about 5/32". An FPE panel and main breaker of this type is shown in Figure 6. The main breaker's output terminal mounting screws and the tiny Allen-wrench that fits them are shown in Figure 7.

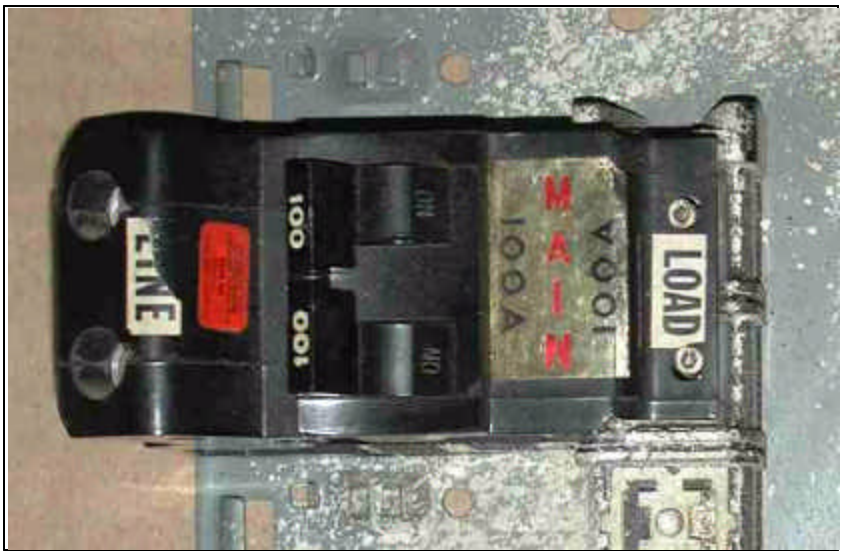


FIGURE 6 - FPE 100-AMP MAIN BREAKER CONNECTS TO THE BUSSBARS THROUGH THE PLATE & POST CONFIGURATION, USING ONE SOCKET-HEAD 8-32 SCREW AT EACH TERMINAL TO ATTACH TO THE CONTACT PLATE.
(The heads of the 8-32 terminal clamping screws are seen above and below the "LOAD" label.)

FIGURE 7 - ONE LOAD-SIDE CONTACT AND ITS 8-32 CLAMPING SCREW, ON THE FPE 100-AMP MAIN BREAKER OF FIG. 6. THE SCREW-HEAD TAKES A 3/32" ALLEN WRENCH, WHICH IS ONLY SLIGHTLY LARGER THAN THE LEAD OF THE #2 PENCIL.
(The larger hole provides clearance for the screw protruding from the stab contact plate)

7. FPE STAB-LOK® PANELS WITH NO MAIN BREAKER

Many of the FPE Stab-Lok® panels that are in homes today do not have any main breaker. This was allowed under the so-called "Rule of Six" in the National Electrical Code (NEC), which states, typically, that "The service disconnecting means ... for each set of service entrance conductors ... shall consist of not more than six switches or six circuit breakers ..." (NEC 1981, section 230-71a, for example.) This reduced the cost of the panel at the time of initial installation, but its nasty side effect is to totally eliminate the safety factor provided by having a main breaker. In the event that a branch circuit breaker jams on an electrical fault, a main breaker would still provide a measure of circuit protection at a higher current trip point. Without the main breaker, there is no circuit protection at all if certain breakers jam. An FPE Stab-Lok® panel with the "rule of six" configuration, normally called a “split bus” type, is shown in Figure 8.

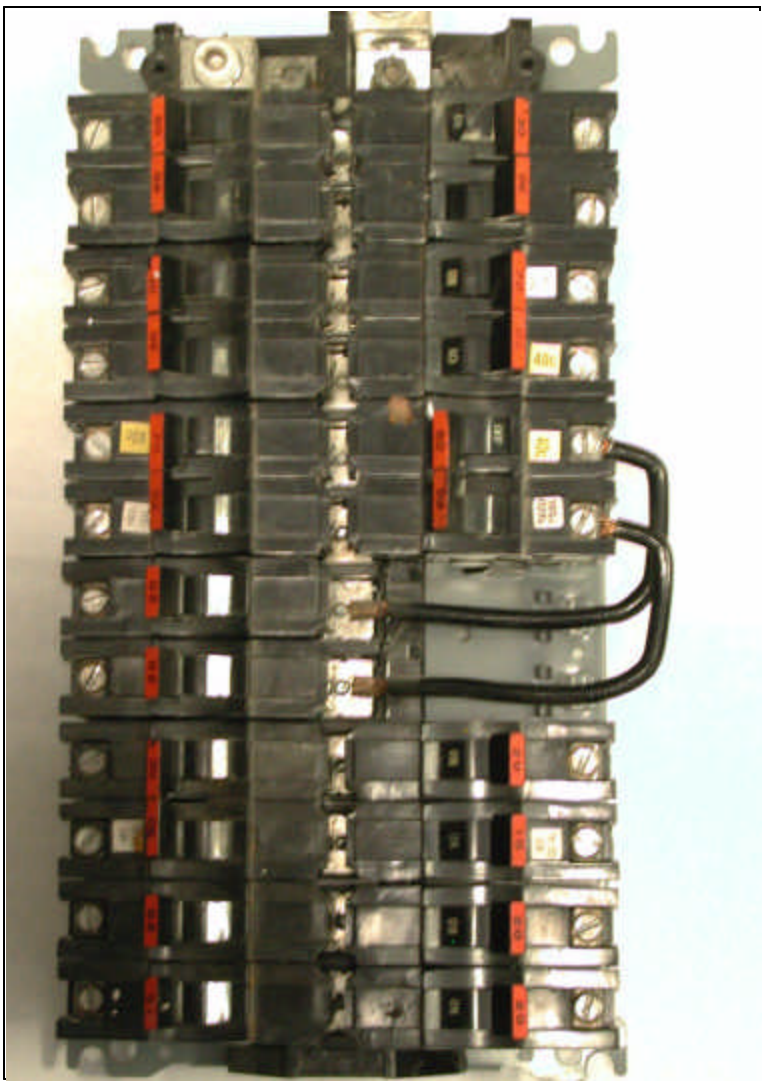


FIGURE 8 - FPE STAB-LOK® "RULE-OF-SIX" (SPLIT-BUS) PANEL WITH NO MAIN BREAKER. THE JUMPER CABLES ON THE RIGHT SIDE FEED THE LOWER SECTION.

There are many different design variations, but the essential element is that in these "rule of six" panels there is no main breaker, and, typically, the lower section of the panel is fed from jumpers coming from the output of one of up to six double-pole breakers in the upper section. The FPE Stab-Lok® double pole breakers have a relatively high probability of jamming when called on to trip, however, as previously demonstrated by the test results presented in Section 2. That means that the home with an FPE "rule-of-six" panel has an unacceptably high probability of having one or more circuits that are totally unprotected, in which the maximum current flow is only limited by what the transformer on the pole can deliver. This is likely to be of the order of 1,000 Amps or more.

7. HAZARDOUS FAILURE - AN EXAMPLE

On first glance, the FPE Stab-Lok® panel previously shown in Figure 8 looks normal. In fact, however, it clearly demonstrates several of the hazardous failure modes discussed in the previous sections. It is one of 28 collected for the recent testing. It is from a home built in 1974, whose new owners had determined in 1999 that it should be replaced. Their decision to replace it was in part prompted by information available on the internet regarding FPE breaker problems.[7] According to the homeowner, who sent it to me for examination and testing, *"We recently had it replaced and found the breaker to the dryer fried in just the way described. Our electrician was astonished. Two others we had bids from dismissed our concerns with contempt."*[8]

Viewing the panel from the front, some subtle signs of overheating (as previously discussed) are evident. These are subtle compared to the view looking down at the top right (dryer) breaker, as in Figure 9. The main service cable connector has been rotated out of the way for better visibility of the damage. The plastic insulator is burnt and cracked. The breaker's internal mechanism can be seen through the hole burned through its side. Figures 10 and 11 show the damage to the separate items.

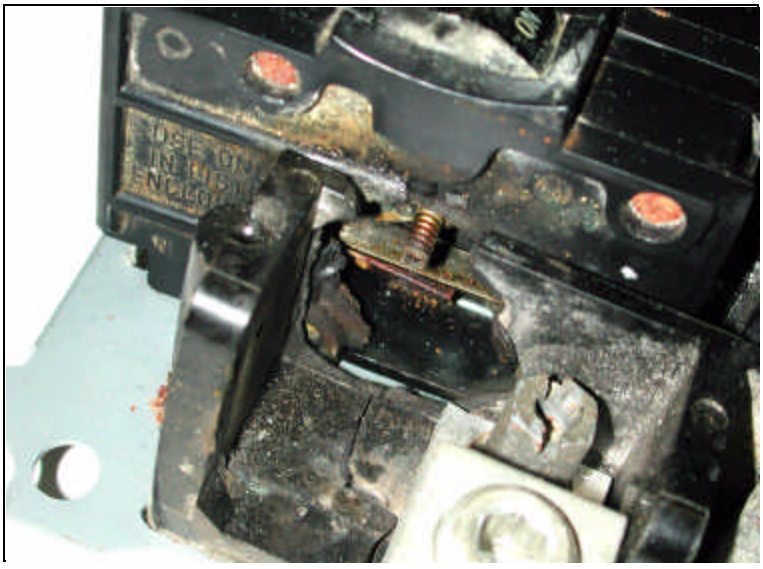


FIGURE 9 - VIEW DOWN TOWARD UPPER RIGHT OF PANEL SHOWN IN FIG. 8. THE FPE STAB-LOK® TWO-POLE 30-AMP BREAKER FED THE CLOTHES DRYER.

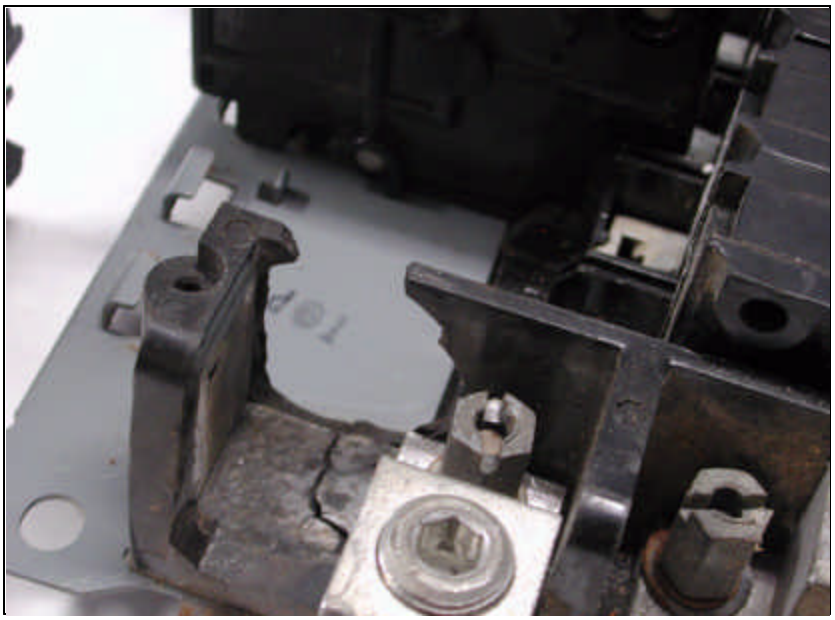


FIGURE 10 - THE DAMAGE TO THE INSULATING STRUCTURE OF THE PANEL (FIG. 8) IS MORE CLEARLY VISIBLE WITH THE BREAKER REMOVED.

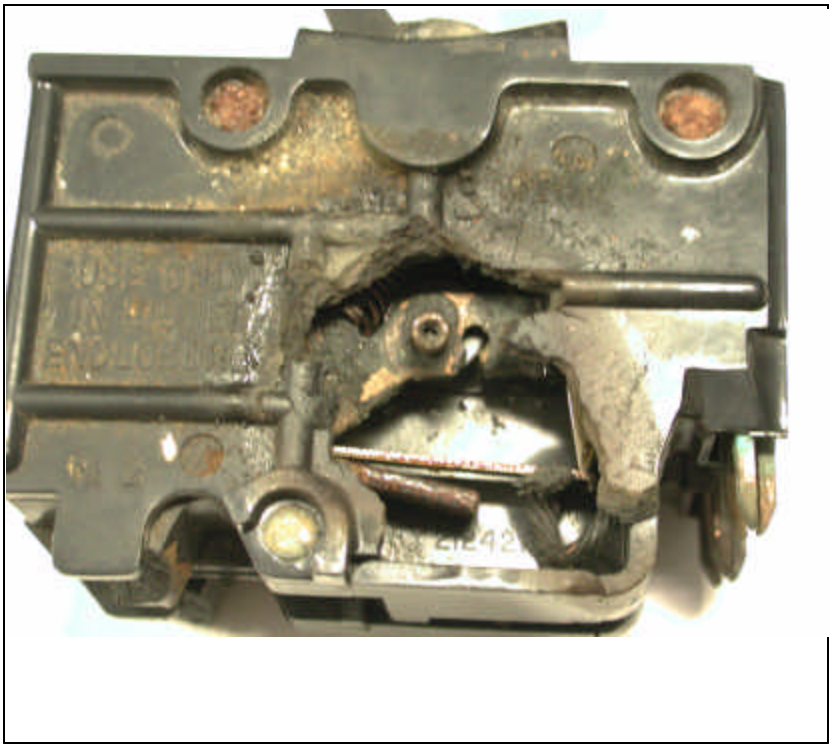


FIGURE 11 - THE FAILED FPE STAB-LOK® DRYER BREAKER (UPPER RIGHT, FIG. 8)

The damage to the breaker, from some previous short circuit or failure event, is exactly as had been demonstrated in the tests done for CPSC.[2, 3, 4] Those tests demonstrated that, when an FPE breaker jammed and the current exceeded about 300% of the breaker's rating, the side of the breaker disintegrated and/or ignited from the heat being generated within the breaker. This is due to resistive heating of the breaker's internal current-carrying components, mainly the bimetal element and the flexible copper braid that connects to it. This is not an arcing failure, although the damage to the insulating materials of the breaker and panel sets the stage for an arcing fault to occur.

There are additional problems in this panel. Overheating damage occurred to the insulation on the backside of the panel. Further, in addition to the dryer breaker that failed (jammed) in the home, two other two-pole breakers from this same panel failed in the lab testing. All this in a panel that looked OK from the front.

Everything in the home was functioning. The dryer worked. Why wouldn't it, since the circuit breaker was jammed in the contacts closed condition? Keep in mind that this panel is one of the "rule-of-six" configuration. Before they replaced this panel, the homeowners unknowingly had a situation where, essentially, the clothes dryer was wired straight through to the power line transformer on the pole, with no functional circuit protection at all.

9. SOME MOMENTS IN THE HISTORY OF THE FPE PROBLEM

In about 1978, the Consumer Product Safety Commission started a project on circuit breakers. CPSC worked together with the National Bureau of Standards (NBS, now NIST), to develop equipment that would allow the testing of breakers in place in a home. Some in-home measurements on various brands, including FPE, were made prior to mid-1980.

In mid-1980, Reliance Electric Company, FPE's parent company, notified CPSC of problems with the FPE two-pole Stab-Lok® circuit breakers. Shortly thereafter, a complex legal tangle began involving several companies, including Exxon, Reliance, UV Industies, and Sharon Steel, centering on allegations of corporate misrepresentations by FPE. See Reference 6 (copy attached) for some of the details as reported at the time. It is reported that, according to Reliance Electric, UL "delisted" virtually the entire line of FPE circuit breakers. Reliance, FPE's "parent" company, reported problems with the full-size FPE two-pole Stab-Lok® breakers to CPSC. They did not report the problems in the rest of the Stab-Lok® line of residential breakers to CPSC.

In 1981 CPSC initiated a specific investigation of FPE's full-size two-pole Stab-Lok® breakers. The results clearly demonstrated that a significant number failed the UL standard tests, and that some would jam with the contacts closed on individual pole overcurrent conditions. There was no basis for disagreement by FPE/Reliance as to the nature of the defects, but they claimed that there was no safety hazard associated with the defective circuit breakers and that the jamming was a result of the applied test and would not occur in normal service.

Initially somewhat cooperative with CPSC, FPE/Reliance eventually refused to take any voluntary action toward recall or warning the public. They challenged the validity of virtually everything that CPSC had done in their investigation, and they took legal action to block CPSC's ability to respond to requests (under the Freedom of information act) for the test results and other documentation related to their FPE Stab-Lok® investigation.

In early 1983, CPSC closed its investigation of FPE breakers, and issued a press release to that effect.[9] The Commission's press release indicates that it was "unable at this time to link these failures to the development of a hazardous situation," that "The Commission staff believes that it currently has insufficient data to accept or refute Reliance's position," and that they did not have the money to develop the required data. The press release provides no information as to the performance defects that CPSC found in their tests, and no information on the possible hazardous consequences.

CPSC did not have the data necessary to rigorously prove a direct relationship between the defective breakers and specific incidents of fire, injury and death. A rigorous connection between defects and injury was required, since the manufacturer of the defective breakers steadfastly refused to cooperate with CPSC toward any recall or consumer safety advisory, claiming that there was no hazard associated with their breakers. The manufacturer essentially challenged the agency to develop the data required to a level that could prevail in court, or drop the issue. CPSC did not have sufficient resources to support the multi-million dollar program that would have been required at that time to develop the data connecting breaker malfunction to injury, and it closed its investigation of the defective breakers.[9]

CPSC's inability to "connect the dots" between FPE Stab-Lok® circuit breaker malfunction and fire/injury incidents stems primarily from the fact that fire investigation and reporting is focused on the cause (ignition source) and its origin (location in the structure). Conventional fire investigation and reporting seldom goes to the depth required to prove with hard evidence that a circuit breaker did or did not function properly. As an example, a fire might start in a bedroom as a result of a short circuit in a table lamp. A fire investigator may suspect that circuit breaker malfunction was a contributing cause, but the ability to prove it is generally lacking. For CPSC, the cost of developing the required methodology, protocols, investigator training, equipment, and then implementing a program to develop the required data was beyond the reasonable reach of the agency's budget.

Two important events had occurred prior to the Commission's vote that no doubt influenced their decision. In 1981, President Reagan took office. The political climate under the new administration was very much pro-industry, and CPSC was on the chopping block from a budget standpoint. The Commission did not have - and was not likely to get - the funds required for a protracted technical and legal battle with FPE/Reliance.

Equally important as background is that, in early 1982, CPSC lost a major battle in court on another electrical product - aluminum wiring. Kaiser Aluminum had challenged CPSC's jurisdiction over house wiring, claiming that it was not a consumer product. After a seesaw series of court decisions and appeals, Kaiser ultimately prevailed. Irrespective of any demonstrated hazard, the final ruling was that CPSC did not have jurisdiction unless it could prove that a substantial percentage of new home buyers contracted directly with the electricians for the installation of the wiring system. That is generally not the case. It is much more common to have the electrician working under contract to the builder or general contractor. After spending a significant portion of their energy and budget on that project over a period of about eight years, CPSC had to abandon their case on aluminum wiring hazards due to that ruling.

In terms of the contractual relationships in home construction, the service entrance panel is analogous to the aluminum wiring. Although other aspects are quite different, the Kaiser appeal could serve as a model for FPE. No matter what level of hazard CPSC might be able to demonstrate associated with the defective Stab-Lok® breakers, they had some chance of losing if FPE chose to challenge their jurisdiction over the product. A precedent of a sort had been set in the aluminum wiring case.

Although a revision of their consumer safety information on FPE has recently been proposed, CPSC has not been seriously active in the FPE circuit breaker issues since their original investigation. Some of their technical documentation is available through the CPSC Freedom of Information Act Office.

The legal tangle involving Exxon, Reliance, FPE, etc., was eventually settled, with very little information made public. Most of the court records from that case are sealed. FPE was out of the circuit breaker manufacturing business by 1986, and the company continues today in the United States only as a legal entity. The contact address is an attorney's office.[10]

In Canada, Federal Pioneer (Schneider Canada) manufactures Stab-Lok® circuit breakers and panels. A recall was announced (by Schneider and The Ontario New Home Warranty Program) of two of their 15-Amp models manufactured between mid-1996 and mid-1997. The announcement states that *"In some circumstances these breakers may not trip. ... If the circuit breaker does not perform as intended, there is potential for property damage and/or personal injury."* (Note: I have included this item because of the quote, which reflects a proper concern for electrical safety, and it is not intended to imply any broader problem with the Federal Pioneer Stab-Lok® line.)

In the 1990's, the emergence in of the internet as a practical means of information retrieval and exchange resulted in renewed attention to the FPE Stab-Lok® circuit breaker performance problems. As a positive result of internet communications, information on the problem has been made widely available, failure reports are being accumulated, and samples from homes are being made available for testing. As a negative result, a marketplace for used FPE Stab-Lok® breakers and breaker/gfi's has emerged. Given the data presented in the previous sections of this report, the purchase of used FPE Stab-Lok® equipment is risky.

In 1999, attempting to counter adverse information posted on the internet regarding the FPE Stab-Lok® breakers, an article was written for the IAEI News (the monthly publication of the International Association of Electrical Inspectors).[10] The author of the article is not identified except as "the former quality manager of FPE, who is a consultant to the company ...", and the article contains a disclaimer that the information that it contains "is neither approved nor disapproved by the International Association of Electrical Inspectors."

The IAEI article does not provide any details regarding the nature of the circuit breaker performance defects and malfunctions that had been uncovered by the FPE, CPSC, and other testing; it only points to UL "listing and labeling" as indicating that they are OK. In its summary, it says, "The gist of this article is that FPE Stab-Lok® load centers and circuit breakers are listed and labeled, and suitable for the usage intended." The article does not mention the fact that UL essentially de-listed virtually the entire FPE line of circuit breakers for a period of time, nor does it deal with the question of the fraudulent testing practices employed by FPE in obtaining and maintaining their UL listings and labels.[6, 11]

The anonymity of the author together with the disclaimer regarding IAEI agreement with the article's content make this article very unusual among articles in IAEI News. Nevertheless, electrical inspectors, having read the article in their own professional organization's publication, are likely to reflect the article's position when dealing with inquiries on this subject. Considering the New Jersey Court's finding of fraud on the part of FPE, the article that FPE/Reliance provided to IAEI news may be viewed as an extension of the fraud -- an effort to "whitewash" a serious breach of corporate and individual ethics and help protect the companies involved.

Presently, there is a class action lawsuit under way against FPE/Reliance in New Jersey. This legal action, initiated about ten years ago, has documented and proven FPE's fraud, that they (FPE) misrepresented to the public that their circuit breakers met the applicable (UL) standards when, in fact, they did not.[11]

10. SHOULD FPE STAB-LOK® PANELS BE REPLACED?

If I inspected your own home and found that it had a fuse box with 1/3 of the circuits over-fused or with pennies behind the fuses, how long would it be before you had it corrected? Would you sleep tight without it being corrected? Would the fact that your house had not had any problem (burned down yet) because of the over-fusing and pennies influence your decision as to whether or not to take corrective action?

Unlike over-fusing and pennies behind the fuses, defective FPE Stab-Lok® breakers cannot be spotted by an inspector or tested by an electrician or homeowner. Without doing a functional test (at overload and short-circuit conditions) on each breaker, one pole at a time for the two-pole breakers, one cannot actually determine the present operating characteristics of a breaker. Which of the 20-Amp breakers really have the trip characteristics of a 30-Amp breaker (same as over-fusing)? Which will not trip at all (same as a penny behind a fuse)?

Most electricians or electrical inspectors can only look at the breakers ("they look OK to me"), and operate the toggle ("they click on and off OK"). But without doing live-current functional testing on all of the breakers, it is impossible to determine which of the breakers in the panel are defective. Will they all trip safely and properly on electrical overload or short circuit? Electrical contractors and inspectors are generally not equipped to do that type of testing, and homeowners or potential purchasers are not likely to have the required budget for extensive specialized testing. In fact, thorough testing would most likely cost far more than changing the panel.

The presence of an FPE panel in a home should be classified as a “Safety Defect”. The FPE Stab-Lok® breakers are primary safety devices of questionable operating reliability. It is not quite correct to call the non-tripping breaker a “fire hazard”. That term should be reserved for the electrical failure that causes ignition. The breaker’s function is to stop certain electrical sequences that could, if allowed to proceed, lead to fire in the building. If an electrical fire hazard involving excess current develops somewhere in the building, the breaker is supposed to trip and minimize the possibility of fire ignition. If the breaker is defective, fire is more likely to result.

There is no question but that the FPE Stab-Lok® panels should be replaced. There is no practical and safe alternative.

REFERENCES

1. "Failure Analysis of Residential Circuit Breaker Panel", Wright-Malta Corp., (by J. Aronstein, for U.S. Consumer product Safety Commission, Project #CPSC-C-81-1455), May 20, 1982 (Contains failure analysis of FPE Stab-Lok® panel that ignited, due to failure of buss-bar interconnections in the backside of the panel.)

2. "Final Report: Calibration and Condition Tests of Molded Case Circuit Breakers", Wright-Malta Corp., (by J. Aronstein, for U.S. Consumer product Safety Commission, Project #CPSC-C-81-1429), December 30, 1982 (Extensive calibration and functional testing of FPE breakers. Substantial percent failures to trip on overload.).

3. "Status Report - Evaluation of Residential Molded Case Circuit Breakers", Wright-Malta Corp., (by J. Aronstein, for U.S. Consumer product Safety Commission, Project #CPSC-C-81-1455), August 10, 1982 (Contains analysis of mechanism of failure of FPE two-pole Stab-Lok® breakers.)

4. "Phase II Report, Evaluation of Residential Molded Case Circuit Breakers", Wright-Malta Corp., (by J. Aronstein, for U.S. Consumer product Safety Commission, Project #CPSC-C-81-1455), March 10, 1984 (Contains experimental analysis of materials, construction, and performance of molded case circuit breakers, including FPE.)

5. Reliance Electric Company press release re: FPE Breakers, July 5, 1980

6. "Exxon Buys a Scandal Along With A Company", Business Week, July 21, 1980, p. 66 (copy attached)

7. http://www.inspect-ny.com/fpe/fpepanel.htm

8. EMail to D. Friedman (manager of site of Reference 7)

9. CPSC press release, March 3, 1983

10. "Federal Pacific Electric Co. Stab-Lok® Update", IAEI News, May/June 1999 p. 16

11. Paritial Summary Judgement decision dated 8/15/02 by Judge Bryan D. Garruto, J.S.C., Superior Court of New Jersey, Law Division: Middlesex County, Docket No. L-2904-97

66 BUSINESS WEEK: July 21, 1980

Exxon buys a scandal along with a company

Exxon Corp.'s $1.2 billion purchase of Cleveland's Reliance Electric Co. last year was designed to give Exxon a base for developing a new energy-saving technology to improve the efficiency of electric motors. What the purchase seems to have bought as well, however, is custody over a burgeoning scandal that involves the charge that defective electrical equipment may have been installed in perhaps 10% of all homes built or renovated over the past decade or more.

The charge, startlingly enough, is being made by Reliance itself. In a little-noticed suit filed in U. S. District Court in Cleveland on June 26, the company accused its own subsidiary, Federal Pacific Electric Co., of having employed "materially deceptive and improper manufacturing, testing, and certification practices" in the production of one of the nation's most widely used lines of circuit breakers. The suit asked the court either to rescind Reliance's March, 1979, purchase of Federal Pacific from UV Industries Inc. or to order UV to repay the $345 million purchase price, plus damages.

A week later Reliance notified the Consumer Product Safety Commission (CPSC) that in-house testing of its Stab-Lok line of two-pole, 220-volt circuit breakers indicates that some are prone to failure after repeated use "at relatively low over-current conditions." Reliance says it has not yet determined whether there is a significant hazard in using the device, and there have been few public complaints against it. But the company has stopped shipment of the product and requested distributors to halt further sales until tests are completed. Other unspecified problems also have been identified on three-pole Stab-Lok and molded-case circuit breakers. Says Reliance President B. Charles Ames: "The circuit breaker business at Federal Pacific has virtually ground to a halt."

Who is responsible? That may be only the beginning. The items involved cost only $16.60 apiece. But if the CPSC determines that they should be recalled, the outlay could be enormous since it would require the services of professional electricians. The cost per house could be as much as $100, trade sources say.

The underlying question in the Cleveland case is who bears the responsibility for this substantial potential liability. The principal defendant is UV Industries, which, after its sale of Federal Pacific, profitably liquidated itself last year over the strong objections of its major stockholder, Sharon Steel Corp. Following the liquidation, Sharon, controlled by Miami financier Victor Posner, bought the remaining assets—and presumably the liabilities—of UV for $518 million in cash and debentures. Distribution of the proceeds was scheduled to take place on July 21, but Reliance is asking for the imposition of a "constructive trust" to prevent "dissipation" of UV's assets. Aside from Sharon's 22% interest in UV's liquidating trust, most of the company's shares are now in the hands of Wall Street arbitrageurs.

Procedural delays. UV Chairman Martin Horwitz strongly denies that he knew anything about Federal Pacific's alleged problems and says the case will be contested. A hearing on a motion to dismiss or transfer the case to New York was set for July 11, probably only the first of a long series of procedural maneuvering.

The Reliance complaint is vague in its allegations of what went on at Federal Pacific. Reliance charges that the company's financial success "was due substantially, if not entirely, to a pattern of materially deceptive and improper practices in the manufacture, testing, and sale" of its circuit breakers. Specifically, the suit claims Federal Pacific used such practices to obtain certification for its equipment from Underwriters Laboratories (UL), whose label is usually required for a product to meet local electrical codes. The CPSC has not yet been told details of the alleged deceptive practices, but a commission staff engineer who

Exxon's new company is suing its own subsidiary for 'deceptive' practices

once worked for UL suggests that the practices may have involved rigging equipment at Federal Pacific's own test facilities in a way that would mislead UL's on-site inspectors.

UL professes surprise at the charge that its inspectors were somehow duped, and its general counsel, David Hoffman, insists that "there is no evidence to support the conclusion that products out in the field pose a substantial hazard to the user." Hoffman further says that because relationships between UL and its client, Federal Pacific, are "proprietary," he cannot even publicly confirm Reliance's open statements that its subsidiary's circuit breaker products were delisted after failing various tests.

The delisting occurred after UL changed testing procedures for circuit breakers following CPSC concern that the product might pose fire hazards. The commission last year asked the National Bureau of Standards to design new test equipment to determine performance under actual conditions in the home. The Reliance case could thus turn into an inquiry affecting the entire $600 million circuit breaker industry.

It was apparently UL's action last fall in delisting nearly 400 circuit breaker labels that started the whole legal process. Reliance says it was originally told that such delisting was routine. But sales had slid so much by early May that it was obvious that the real problem was not the failure of circuit breakers to gain UL approval but "deception" in obtaining certification over a long period of years.

Reliance has suspended with pay Federal Pacific President Harry E. Knudson Jr. and four other key executives. "The men are long-term employees and their integrity is not being called into question," Reliance said in a statement distributed on July 1 to all Federal Pacific employees. Contacted at his home in Watchung, N. J., Knudson refused comment. ■