CRANE ENGINEERING

PROBE

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Short Circuit

Is it your fault?

We all do it. We lull ourselves into rather unwarranted complacency due to the sheer constancy of success. We flip the wall switch, and the light comes on. And on those occasions when it does not, we silently curse the hobgoblin of tungsten and screw in a new light bulb.

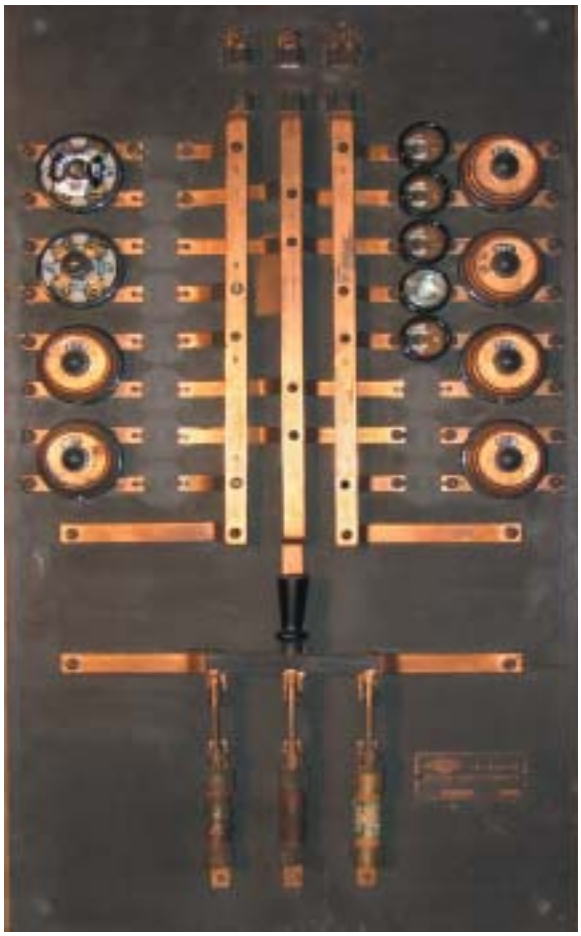
But the fact is that electrical systems do not always work as intended, and when they do not, it is the art and science of circuit protection that stands between this failure and disaster.

The two most common electrical system failures are overloads and faults, commonly called short circuits. Strictly speaking, an overload is usually not a failure of the circuit at all – it results simply from the circuit being asked to do more than it was designed for. If, while you are preparing your famous Sunday breakfast buffet, you run your toaster, your waffle iron and your coffeemaker all at the same time and all on the same circuit, you may well overload the circuit, tripping the protective device before the circuit conductors overheat enough to create a hazard.

Strictly speaking, an overload is usually not a failure of the circuit at all . . . .

On the other hand, many short circuits, defined loosely as any situation where the current flows outside its intended path, are legitimately considered to be circuit faults or failures. They may be due to such events as insulation damage or thermal breakdown, and they tend to make sparks.

Modern circuit protection in the form of fuses and circuit breakers protects against many kinds of both overloads and faults, albeit by very different mechanisms. (There are, of course, specialized forms of each for purposes not covered here – we can cover that at a later date!) The heart of a fuse is the fusible link, a band of low-melting-point metal through which the circuit current flows. It is calibrated to melt and open the circuit either when a slightly excessive current flows for a long time (overload) or when a vastly excessive current flows for an instant (short circuit). Fuses are one-time devices and must be replaced if they operate.



State-of-the-art circuit protection and distribution panel board from circa 1920. Bare copper bars were bolted to a 1-inch machined slate base, with rotary switches and plug fuses. Weight: 60 lb!

Circuit breakers essentially are fabricated of a heat-sensitive bimetal strip, an electromagnet, and a set of contacts to break the circuit under the command of the bimetal strip (overload) or electromagnet (short circuit). Ordinarily they may be reset after operating to protect the circuit again and again.

In addition to this conventional circuit protection, which has existed in principle since the days of

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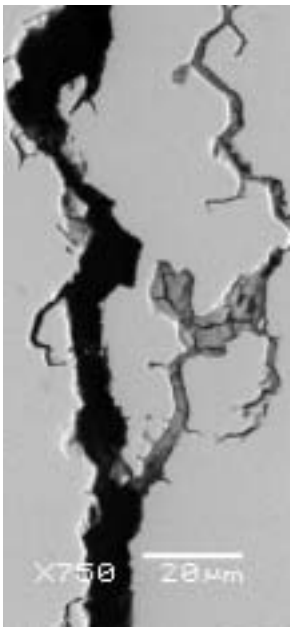
Stress Corrosion Cracking

Achilles heel of stainless steel



This micrograph taken using Crane Engineering's scanning electron microscope shows stress corrosion cracking in type 316L stainless steel. The main crack has perforated the thin gauge material and caused leaking. Numerous smaller cracks can be seen around the main fracture. Chloride-containing residues were found on the cracked surface, which confirms the importance of properly specifying steels for the conditions.

Designers often select stainless steels because they 'never corrode.' This thinking can lead to the occasional misuse of stainless steels in environments that can cause stress corrosion cracking (SCC). SCC is defined as a brittle failure mode of an otherwise ductile metal, resulting from the combined action of tensile stress and a specific corrosive environment. For stainless steel, the corrosive environment is aqueous solutions that contain chlorides. On the other hand, copper alloys are susceptible to SCC in the presence of ammonia.

Stress corrosion cracking always involves cracking – not simply corrosion. The cracks can be intergranular or transgranular, and typically multiple cracks with branching are found in the failed component. Since visible cracking is observed, there is a tendency to discount how the component is affected by its environment and focus instead on stress as the cause. In reality, chloride levels as low as 25 parts per million have been shown to cause SCC in type 304 stainless steels – so "fear may not be a factor," but the environment is!

SCC involves an incubation period that begins at a microscopic level. Later the crack grows to detectable size and ultimately leads to leaking or structural failure of the component.

Chlorides are by far the most common cause of SCC, not only in stainless steels, but also in certain brasses. The higher strength aluminum grades are also susceptible to SCC when exposed to aqueous chlorides. Cleaning solutions, disinfectants and bleaches are common sources of chlorides, which can lead to stress corrosion cracking of metals.

By evaluating the environments in which stainless steels will be used, designers can reduce the potential for stress corrosion cracking and ultimate component failure.

Dave Kramer, P.E., Metallurgical Engineer
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To Grill or Not to Grill

That is the question

The grill has been busy at my house this summer. No doubt many of you have tossed a steak or chicken on the always-faithful charcoal grill as well. All you have to do is light the coals and within no time you are happily grilling a plethora of culinary treasures. But have you ever thought about the chemistry that gives the meat its taste and visual appeal?

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An estimated 90 percent of Americans take part in barbecues each July 4. Especially in Minnesota, it's hard to resist outdoor grilling. But just how safe is meat once it's grilled?

Common Scents

Dogs dig. I personally find it a rather pedestrian experience to engage in the ordinary dig and prefer the archeological and archive form of digging. It is not surprising that this should produce results beneficial to my main job, Canine Executive Officer, to come up with source documents for the way we live and work today. In fact I am in possession of an original scroll of divine guidance, which I have translated for you:

And the Lord said unto Noah: "Where is the ark which I have commanded thee to build?"

And Noah said unto the Lord: "Verily, I have had three carpenters off ill. The gopher wood supplier hath let me down—yea, even though the gopher wood hath been on order for nigh upon 12 months. What can I do, O Lord?"

And God said unto Noah: "I want that ark finished even after seven days and seven nights."

And Noah said: "It will be so."

And it was not so. And the Lord said unto Noah: "What seemeth to be the trouble this time?"

And Noah said unto the Lord: "Mine subcontractor hath gone bankrupt. The pitch which Thou commandest me to put on the outside and on the inside of the ark hath not arrived. The plumber hath gone on strike."

And the Lord grew angry and said: "And what about the animals, the male and the female of every sort that I ordered to come unto thee to keep their seed alive upon the face of the earth?"

And Noah said: "They have been delivered unto the wrong address but should arriveth on Friday."

And the Lord said: "How about the unicorns, and the fowls of the air by sevens?"

And Noah wrung his hands and wept, saying: "Lord, unicorns are a discontinued line; thou canst not get them for love nor money. And fowls of the air are sold only in half-dozens. Lord, Lord, Thou knowest how it is."

And the Lord in His wisdom said: "Noah, my son, I knowest. Why else dost thou think I have caused a flood to descend upon the earth?"

Keep your nose moist and your tails up. 'Til next time. . . .

Max, Canine Executive Officer
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"To Grill or Not to Grill" continued from page two

That beautiful charcoal-induced color that gives a steak its fantastic flavor is actually the result of a class of compounds referred to as polyaromatic hydrocarbons. Unfortunately, these types of compounds are potentially cancer-causing substances. And that's not the only bad news – the charcoal briquettes actually give off sulfur dioxide, which causes acid rain, and the lighter fluid produces volatile organic compounds, which create smog. In fact, certain areas, such as Los Angeles, actually have legislation controlling the emissions from lighter fluids.

Those of you moved enough by the threat of carcinogens on your food might consider the other extreme – cooking without a flame by using your handy microwave. No nasty compounds, no emissions, no smog – no sweat – so you think. Microwaves cook by rapidly moving molecules past one another to heat the item. This thrashing motion also causes molecules, such as vitamin B-12, to break down into inactive degradation products. In fact, a microwave can actually induce such intense turbulence that the food's DNA is scrambled to such an extent that the body can no longer recognize the food.

Certain areas, such as Los Angeles, actually have legislation controlling the emissions from lighter fluids.

So if you heat your milk in the microwave, your body may not recognize it as milk. As a result, your body actually has to deal with an 'unknown' substance.

So, what to do? Some studies done at the University of Hawaii show that the negative effects of meats grilled over charcoal can be reduced by eating lots of green vegetables. That seems a fair compromise – and I'm sure not nuking my New York strip in that box over the sink. Enjoy!

Bill Katz, Ph.D., Consulting Chemist
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Check out SEM mystery image on page 4

(And the answer is. . .)

The answer to "Some of you may have a flair for using this – or maybe you're just stuck on what's behind it."
Taken using Crane's scanning electron microscope/electron dispersive spectrometry, the mystery image in this issue is a felt-tip pen (a Flair®) held in place by cellophane tape. Be sure to look for another mystery image in our next Probe newsletter.

CROSS-SECTIONS

Take a look at our new name and logo! We recently shortened our name to Crane Engineering, dropping the reference to forensic services. Forensic services continues to be an important part of our business, but we wanted everyone to know we're not limited in our service offerings. You'll also see we gave our logo a slight makeover, retaining the forest green and gold that so many have come to recognize.

Tom Crane and Scott Sollars attended the American Society of Gas Engineers Gas Engineering Training Conference in Anaheim, Calif.

In May, Bill Katz and Dave Kramer held a seminar titled "Probing Problems and Failures." The seminar was designed for those responsible for understanding and solving materials problems in industry. It addressed the fundamentals of current technical analysis and presented real-world examples of problem-solving in industrial settings. Attendees indicated they are interested in additional sessions, so stay tuned for future seminar notices.

SEM MYSTERY IMAGE

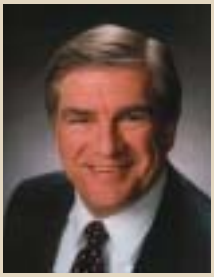
Some of you may have a flair for using this – or maybe you're just stuck on what's behind it. See p. 3 for the answer to this issue's mystery image.

"Short Circuit" continued from page one

Thomas Edison, homes now also contain ground fault circuit interrupters and are just beginning to be provided with arc fault circuit interrupters, both topics for another session!

Until then, if the kitchen conveniences required for your famous Sunday buffet should overload the circuit, go ahead and unplug something, wait a few minutes for the circuit breaker to cool, and reset it. Or, in the case of a fuse, replace it – but never with one larger than the circuit rating, typically (not always) 15 amps for homes.

If you are installing a bracket for a shelf to store your collection of famous Sunday buffet cookbooks and make sparks fly by unluckily driving a screw through a wire in the wall, leave the breaker off and call a qualified electrician.



Bill Sutherland, electrical engineer, is the newest member of Crane Engineering's team. His more than three decades of wide-ranging electrical engineering experience complements Crane Engineering's other engineering and analytical disciplines. Bill brings significant expertise to bear on questions regarding the behavior of electrical systems and equipment under both normal and fault conditions.

With nearly 25 years as a consulting electrical engineer in private practice, Bill has extensive background in forensic engineering; design and design management; system analysis; and third-party equipment certification.

A licensed professional engineer in 49 states and the District of Columbia, Bill is a proponent of engineering licensure. He is a past chair and serves on the Minnesota Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience and Interior Design.

Stay tuned for more on electrical engineering in future issues of the *Probe* or email me directly if you wish to discuss fuses, circuit breakers and more!

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