

The Phenomenon of Zinc Whisker Growth and the Rotary Switch

(or, How the Switch Industry Captured the Abominable Snowman)

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The information set forth in this article was, unfortunately, developed within the confines of a lawsuit, which is generally not the best place for a free-flowing exchange of information. The suit was filed by a medical-device maker against a rotary-switch manufacturer. The authors of this article are the legal counsel and the engineering manager for the rotary-switch company. Condensed into the following paragraphs is the history of the very long and convoluted legal action, which ultimately resulted in an engineering lesson for a lawyer and something of a scientific breakthrough for the rotary-switch business. It is hoped that this material will be beneficial to medical-device companies, switch manufacturers, zinc electroplaters, and their legal counsel, and will help to avoid liability under product liability, breach of warranty, negligence, and consumer protection theories and statutes. Consumers of switches and electroplating services should also profit by this information.

A SAD SONG

This story begins with the apnea-monitor company. An apnea monitor is a medical device designed to sound an alarm if the patient monitored ceases breathing. It is frequently used on infants to avoid sudden infant death syndrome and on adults recovering from anesthesia.

The apnea-monitor company purchased switches for use in a critical application in their monitors. In the initial stage of the relationship, the switch manufacturer did not know the specific application for which the switches were to be used.

The switches were purchased by the apnea-monitor company from approximately February 1987 through March 1988. In October of 1987, the apnea-

monitor company received a complaint that the alarm in one particular monitor had failed. The problem was traced to a leakage to ground in the rotary switch. The switch was removed from the monitor and returned to the switch company. The standard battery of tests were applied, but the switch company could not reproduce the failure and communicated the same to the apnea-monitor maker. Ultimately, both parties concluded that the problem was nothing more than a fluke and dismissed further testing.

Almost a full year later, in late September of 1988, a second complaint was received that described problems identical to the first complaint. This switch was tested in the same manner by the switch company, but again the failure could not be reproduced and both events remained a mystery.

A third complaint occurred in December, 1988, and more followed in early 1989. They were all systematically reported to the switch manufacturer, yet none of the failures could be duplicated. In March of 1989, the switch company changed the standard test procedure in an effort to duplicate and represent the actual application that had by then been disclosed. Finally, the problem was successfully reproduced by the switch company.

Despite the fact that the switch company was able to observe the problem, it still could not identify the cause. The problem exhibited an intermittence that could not be explained. Sometimes leakage appeared repeatedly when tested at low voltage, but not while tested at high voltage. At other times, the problem existed when the switch was set at one position, but would temporarily disappear while set at another position. It was difficult to establish a consistent pattern among the switches that demonstrated the

leakage-to-ground problem. In an effort to resolve the issue, the switch manufacturer introduced the apnea-monitor company to an outside consultant who studied the problem. This consultant believed that the culprit was excess solder flux created in the assembly of the switches into the apnea monitors. At his suggestion, the soldering procedures of the apnea-monitor company were modified; however, the problem still persisted.

Simultaneously, an employee of the apnea-monitor company (who possessed technical expertise) suggested silver migration as a possible cause. To test his theory, he chose an objective laboratory outside the confines of his employer. He provided new, or "virgin," switches as well as soldered switches to the laboratory. The opinions of the laboratory personnel were inconclusive and the silver migration idea was discounted; however, they did observe that the leakage was common to ground in both the virgin and soldered switches.

The apnea-monitor company filed suit against the switch manufacturer, claiming multiple violations of a consumer protection statute, strict product liability, negligence, fraud, breach of express warranty, and breach of the implied warranties of merchantability and fitness for a particular purpose. The apnea-monitor company claimed that the switch failures and a subsequent total recall of the product had ruined its reputation and was responsible for the eventual permanent closure of the business.

The switch manufacturer then hired an expert witness who had designed and manufactured rotary switches for over 40 years. His initial opinion was that the leakage was caused by contamination from an unidentified source.

At this juncture, four experts had reached four different conclusions: the

outside consultant introduced to the apnea-monitor company by the switch manufacturer believed the problem was caused by excess solder flux; the apnea-monitor company's employee espoused the silver-migration theory; the laboratory hired by the apnea-monitor company reached an inconclusive result; and the experienced switch designer believed the cause to be contamination. There was no clear evidence to sway the case in favor of or against any of these theories.

Finally, after the case had been pending for a considerable length of time, the apnea-monitor company hired yet another consulting expert—a Ph.D. electrical engineering professor from a university—who researched the project for nearly a year without being able to identify the cause of the leakage. He was ready to abort the project when, one day while pondering the problem, he held a disassembled switch before an open window. When sunlight struck the surface of the switch's detent plate, a small reflection on the surface of the plate caught the professor's eye. Magnification revealed minute tentacles that appeared to grow out of the plate. The professor determined that the detent plate was steel covered with zinc electroplating. A hunt for scientific literature on zinc electroplating led him to believe that he had seen zinc whisker growth on the surface of the plate. He concluded that when zinc whiskers reached a sufficient length, they came in contact with another part of the switch that was conductive, thus causing the leakage to ground.

Zinc whisker growth is a condition that results when zinc is placed under compressive stress, such as the stress created in the electroplating process. To alleviate this stress, the zinc plated parts grow tiny filamentlike projections (whiskers) from the surface of the zinc. There is a difference of opinion as to how fast or how slow zinc whisker growth occurs, and the rapidity of the growth appears to depend on a variety of circumstances. For example, research revealed that variables in the plating process could be adjusted to either enhance or retard the likelihood of growth. Other variables include the amount of brighteners used, the temperature of the plating bath, and current density.

THROUGH THE LOOKING GLASS

The switch manufacturer knew that tin and cadmium had whisker capability, yet had no prior knowledge or experience with the phenomenon of zinc whisker growth. The experienced switch designer (who served as the expert witness for the manufacturer) had only remotely heard of the zinc-whisker-growth concept. Because he considered zinc whisker growth to be a new discovery, both the switch designer and the manufacturer were surprised to learn of the already confirmed existence of zinc whisker growth within certain industries. Apparently certain elements of the scientific community had already become familiar with zinc whisker growth, but information of its existence had not yet reached the switch industry.

Therefore, all the companies that had applied zinc electroplating to both the detent and rear plates of the switches were subject to liability and named as parties in the lawsuit. They, too, were completely without knowledge of the zinc-whisker-growth phenomenon.

HOW COULD IT HAPPEN?

How could it happen that a solid, experienced, and reputable switch manufacturer that had produced switches with a time-tested pattern of zinc plated parts for over 55 years was not aware of the problem of zinc whisker growth?

The answer lies in the specific design of the rotary switch when used in comparatively high-voltage applications. This same switch was rarely used by consumers for low-voltage purposes, but in recent years, low-voltage applications had become more and more common. This gradual increase in low-voltage use eventually led to the unfortunate experiences described.

The fragile nature of the zinc whiskers explained why the switch manufacturer incurred so much difficulty in its attempts to reproduce the leakage. The application of high voltages of electricity burned and destroyed the whiskers through incineration. The destruction of the whiskers occurred in the normal test procedures used within the rotary-switch industry.

The elements of the scientific com-

munity already knowledgeable of zinc whisker growth were the aerospace and communications industries. These industries traditionally form the cutting edge of technology, whereas most other industries tend to lag comparatively behind. These two industries' combined knowledge of zinc whisker growth had not yet been introduced to mainstream rotary-switch electroplating or the medical-device industries.

SAY IT AIN'T SO!

The switch company had no intent to harm and was completely without knowledge of the problem that could be caused by low-voltage use of switches with zinc parts. Unfortunately for it, in most states the law imposes liability on the manufacturer of a product that is found to be unreasonably dangerous, even if the manufacturer does not intend for the product to be dangerous, or is unaware that it has certain dangerous propensities in what is thought to be an obscure use.

The catalogs used to promote the product stated that the subject switches tested to a maximum value of ten thousand megohms. Case law has held that catalog assertions are express warranties, even though a minimum value was not stated in these catalogs. It was argued that the customer should be able to assume the switches would adequately perform below advertised electrical performance levels. The analogy used to justify this assumption included a high jump of seven feet. If a person can high jump seven feet, it is natural to assume that he can also jump less than seven feet, and it is almost automatic to assume that he can jump as low as a few inches.

In addition, under the law of strict product liability, the focus is on the condition of the product, rather than on the intentions or conduct of the defendant. The law is that if the product is found to be defectively dangerous, then liability can be imposed. It does not matter that the defendant was not aware of the defect.

The authors of this article do not intend to argue that the existing laws concerning product liability are right or wrong. Rather, it is their intent to make concerned persons aware of the potential difficulties that are described herein.

A LESSON WELL LEARNED

The important lesson learned is that zinc plated parts are inappropriate for use in rotary switches intended for low-voltage application. The switch company commenced redesigning the switch promptly upon a conclusion of the suit.

This lawsuit, like most, was settled by agreement of the parties. Had it gone to trial, each party would have run the risk of losing. The parties agreed that a compromise was more palatable to each than were the uncertainties of a trial.

CONCLUSION

In 1492, the world was flat and only Justice Columbus dissented. In 1929, the African gorilla was only a myth until explorers verified the animal's existence. Zinc whisker growth has been to the switch industry what the abominable snowman was to the average citizen: a myth. As time goes by, the world grows smaller as more and more mysteries are solved. It is regrettable that in modern-day life, the dissemination of information is sometimes driven by litigation. **MF**