"SLIPPERY" Issues in Aquarium Fire Losses

By Peter A. Lynch[1] and Chris Bloom[2]

Complex issues should be evaluated when investigating fire losses involving aquariums. A call comes in involving an aquarium suspected of being the cause of a fire, what are your first steps? Preserve the scene to recover all of the components related to the aquarium, comes to mind.

TANK COMPONENTS

Aquarium tanks are made of glass or acrylic. Aquarium producers assert that acrylic aquariums last longer than glass tanks.[3] Tank components can include but are not limited to air pumps, heaters, air stones, lights, power strips, and under gravel filters. In the case of salt or brackish water aquariums, equipment will include the previously mentioned equipment as well as additional components such as Protein Skimmers, High-Intensity Discharge Lighting (Compact Fluorescent Lighting and/or Metal Halide), Super Filtration Pump Systems, Sump Pump Systems, and other components. Identifying the manufacturer of the components can be challenging. Resulting to invoices or credit card receipts may be necessary, if the components are badly damaged by the fire.

Exemplar components may have to be obtained by E-Bay or similar services. All available components should be preserved for examination by a qualified cause and origin investigator in place, and other necessary consultants to potentially include an electrical engineer, a mechanical engineer, and an aquarium maintenance expert.

Those tank components may initially need to be x-rayed or non-destructively viewed. If the manufacturer, seller, or tank maintenance company can be identified, they can be given the opportunity to evaluate those components at the scene. However, evidence often times must be moved/preserved in order to determine the identity of the manufacturer, seller, or maintenance company. If that happens, such movement or alteration should not be considered spoliation of evidence.[4]

HOW AQUARIUMS WORK

Aquariums typically operate with many of the components noted above. However, larger aquariums or those handling salt or brackish water systems can use even more complicated components. These larger aquariums are becoming more common in restaurants, professional offices and other locations.

Generally speaking, saltwater aquariums closely mimic the real life conditions of the open ocean. "The salt content of most natural lakes, rivers, and streams is so small that these waters are termed fresh or even sweet water. The actual amount of salt in fresh water is, by definition, less than 0.05%. Otherwise, the water is regarded as brackish, or defined as saline if it contains 3 to 5% salt by volume. The ocean is naturally saline at approximately 3.5% salt (see sea water). On average, seawater in the world's oceans has a salinity of ~3.5%. ...This means that for every 1 liter (1000mL) of sea water there are 35 grams of salts (mostly, but not entirely, sodium chloride) dissolved in it." [Source: http://en.wikipedia.org]

STRAY VOLTAGE IN AQUARIUMS

Electrical voltage can enter the aquarium system by several methods. For example, stray voltage can enter tanks through common tank components. When a component begins failing, it can leak electricity into the tank. That leakage is called stray voltage. An investigator needs to evaluate if that stray voltage was a factor in any aquarium fire.

SALT CREEP

One potential fire related problem with aquariums is based upon the common phenomenon called "Salt Creep". Of all the systems and components commonly used on aquariums, two components play the most direct role in salt creep are the heater, and if equipped, an aerator (commonly known as a bubble/air stone).

Salt creep occurs when the tank sprays fine mists of salt water into the atmosphere from the bubble/air stones, or leaches the heated salt water into the environment through evaporation. The fine saltwater mist condenses and coats the walls of the tank, the tank components, and even the power cord wiring. Once the final evaporation of the water occurs, salt crystals form, and further propagate; growing to form elongated crystals visible to the eye. Because salt creep formations are electrically conductive, they in fact create an artificial pathway from the aquarium components to the water.

As mentioned, another form of salt creep can form from the evaporation of the saltwater from tank. As saltwater

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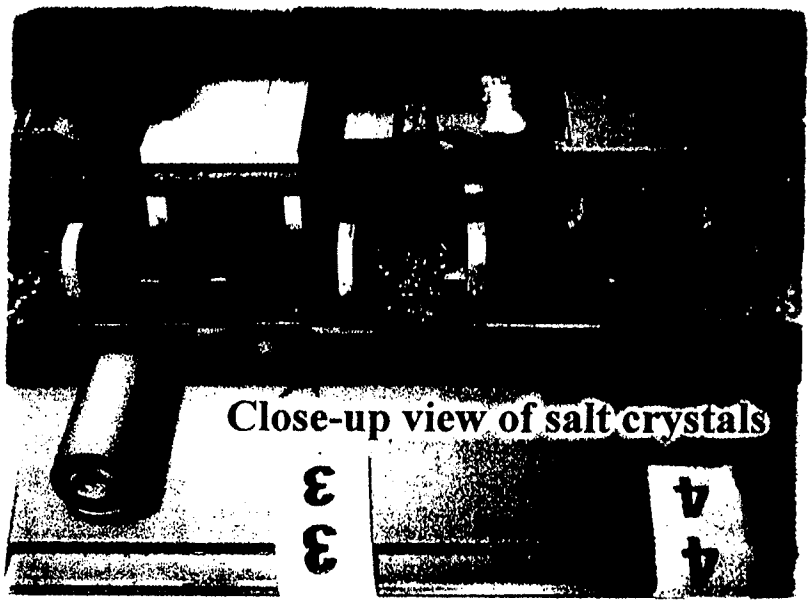
aquariums need to maintain the water temperature between 77°F and 82°F for most invertebrates and fish species, they commonly employ one if not several heaters (depending upon the tank size and capacity). In addition, the use of overhead lighting to illuminate the tank also adds additional heating to the water and increases the evaporation rate of the water. While all lighting can cause this to occur due to their close proximity to the water surface (several inches maximum), the use of High-Intensity Discharge Lights, such as Metal Halide, greatly increases the heating rate.



Close-up view of salt crystals

A far less common but more invasive form of salt creep can form right after recommended water changes. It is recommended under ideal conditions that every two weeks, ⅓ of the volume of water be changed out with newly created saltwater. The problem with this action is that during water changes, if any saltwater is not carefully and completely cleaned up immediately, the water can drip down the various surfaces and once evaporated, leave the salt crystals behind. Such actions are known to create complete electrically conductive pathways down the power cords to the electrical receptacles, greatly exacerbating the problem. Such conditions are prone to causing severe electrical issues at the conductors for the power strip / wall outlet receptacle.

It is common to find, however, that salt spray or salt creep buildup can invade the electrical connections of the light, power head or water pump. The problem with this scenario is that an unintended electrically charged pathway is created from the component to and into the water. That electricity can go to ground through the salt spray/creep, causing unintended heating of material it comes into contact with.

It has been reported by aquarium enthusiasts that such conditions can allow transient voltages to flow from the electrical components through the tank water, to the nearest ground. Such transient voltages can cause not only component failures and damages, but also can cause harm to the fish and other residents of the tank. Because of this potential, it is highly recommended that all equipment (filters, pumps, lights, heaters, air/bubble stones, etc) be checked regularly and when needed, cleaned of all salt creep.

It is a highly recommended practice in the field that all electrical power cords to components contain a "loop" in the cord, to prevent salt creep from accessing the power connection at the receptacle. In addition, it is also a recommended practice that when utilizing a power strip, that not only the power cord contain the "loop", but also that the power strip be mounted to the underside of the tank stand. If the industry recommended practices are followed, the risk of an electrical failure and fire from such components can be minimized, but not eliminated completely.

A recent case summary helps illustrate the salt creep – salt spray hazard. A commercial building fire was investigated by the San Diego City Fire Department. The Fire Department Investigators identified a fish tank aquarium and its components as the only electrical components in the area of origin in the corner of the room. The report concluded "this fire was the result of an electrical failure of the conductors within the wood stand in the northeast corner of the northwest office."[5]

The aquarium and its components had been installed twelve years earlier. The tank and its components were taken care of by an aquarium maintenance company. This was a glass aquarium salt water tank. The remains of the tank were preserved by the private cause and origin investigator after the initial inspection by the Fire Department. A civil action was later filed against the maintenance company for improper maintenance of the aquarium leading to the fire.

The fire investigators and electrical experts used a process of elimination to identify the area of origin and cause of the fire. This included reports of the first in Fire Captain and witness interviews after the fire. Later deposition testimony identified a recurrent problem with salt trails on the outside of the tank, which was on a triangular stand. However, the tank components below the stand, behind a triangular couch, were never inspected. The air pump and power head electrical cords in close proximity to the salt trails, were never

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cleaned or inspected by the maintenance company.

The applicable sections of the 1996 National Electrical Code were:

Handbook, p. 29, section 110-7 stated:

Insulation Integrity. All wiring shall be so installed that, when completed, the system will be free from short circuits and from grounds other than as required or permitted in Article 250.

Insulation is the material that prevents the flow of electricity between points of different potential in an electrical system. Failure of the insulation system is one of the most common causes of problems in electrical installations.

. . .

The principal causes of insulation failures are . . . moisture, dirt, occurring . . . after installation. Insulation can also fail due to chemical attack. . . .

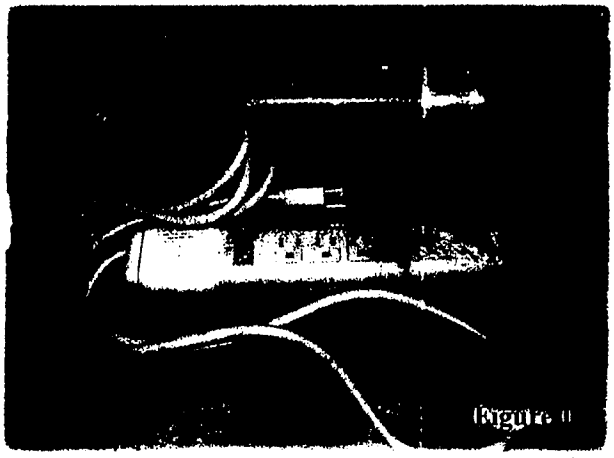
The National Electric Code Handbook, p. 35, section 110-11 stated:

Deteriorating Agents. Unless identified for use in the operating environment, no conductors or equipment shall be located in damp or wet locations, where exposed to ... liquids, or other agents having deteriorating effect on the conductors or equipment; nor where exposed to excessive temperatures.

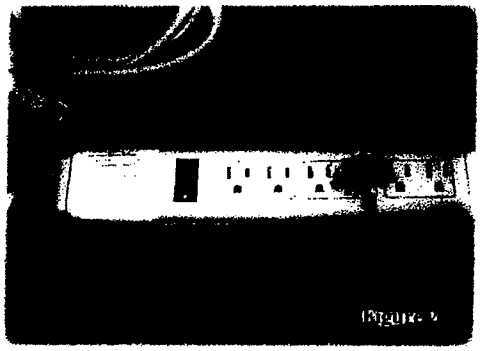
The plaintiff's electrical engineer identified salt creep as one failure mechanism based on the above noted electrical code provisions and evidence referenced above. Defendant's electrical engineer did not dispute that salt creep can be a viable mechanism to cause a fire under the right circumstances. The case resolved for 95% of the defendant maintenance company insurance policy limits for this large commercial fire case.

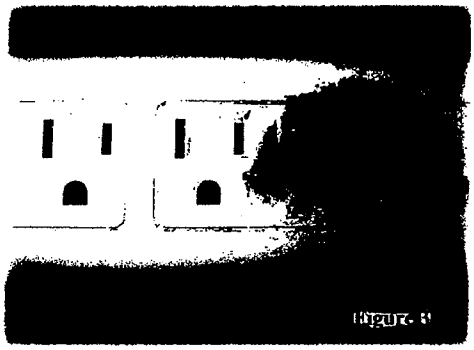
EXEMPLAR ANALYSIS

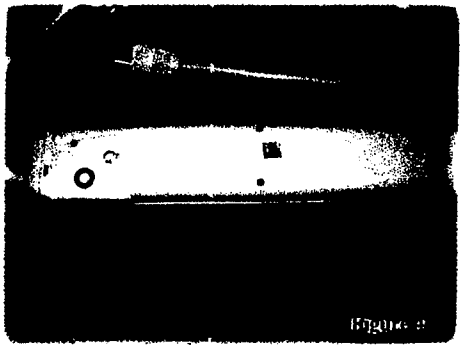
Electrical Engineer Rick Kovarsky of Pyro-Technical Investigations, Inc. located in Cincinnati, Ohio was sent two outlets strips that had been used in conjunction with salt water aquariums. One of the strips showed fire damaged on the face of one of the receptacle locations. The other outlet strip appeared unremarkable (see Figure 1).

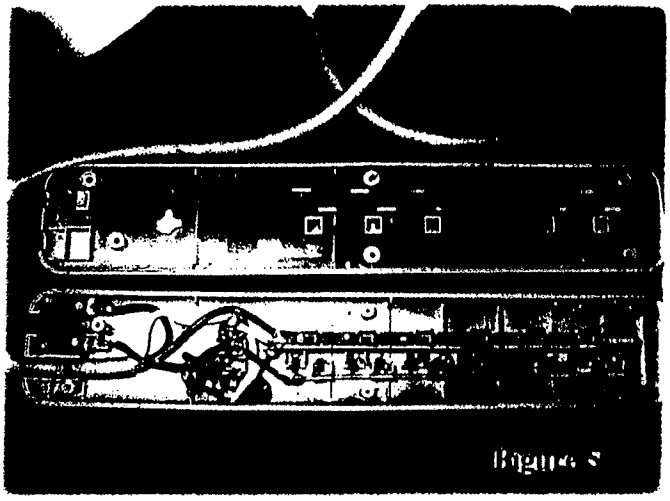


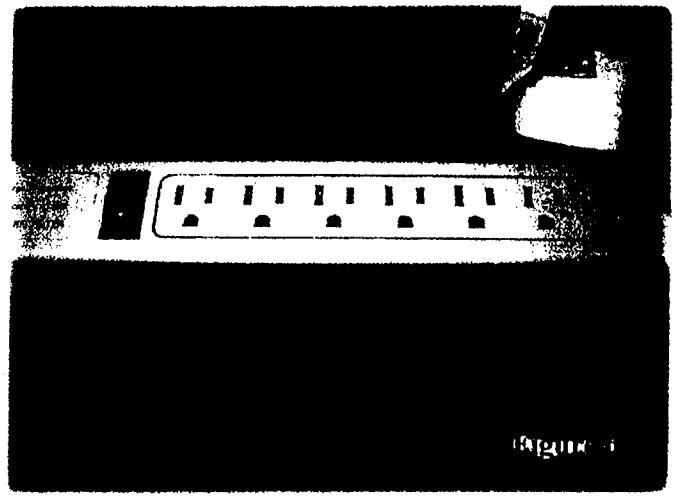
Closer examination of the fire damaged outlet strip noted that it consisted of six (6) receptacle locations. The fire damage was at the fourth receptacle from the switch end of the strip. It was apparent that no appliance cord had been plugged into the receptacle location where the fire damage had occurred. The case of the outlet strip showed no other evidence of heat or fire damage (see Figures 2 through 4).











The housing for the outlet strip was taken apart. There was some smoke exposure to the interior of the housing, but no direct fire damage was noted on the interior portions of the plastic housing. The metal receptacle rails were intact (see Figure 5).

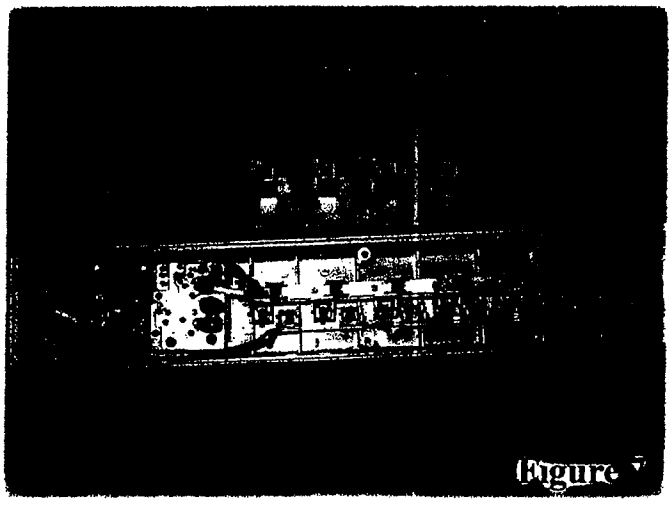
The second outlet strip was then examined. It appeared unremarkable from the exterior. Upon taking apart the housing, deposits were noted on the receptacle rail. (see Figure 6).

Both outlet strips were sent to microscopic and SEM analysis. On the undamaged outlet strips, it was determined that the deposits noted on the receptacle rails were salt crystals. On the fire damaged strip, the deposits noted on the receptacle rails were copper oxide, most probably a result of the fire. No salt crystals were found on the interior of the strip. Salt crystals were found, however, on the exterior of the outlet strip, particularly in the vicinity of the fire damaged receptacle location.

The fire damage to the outlet strip clearly originated on the plastic face of the receptacle. There was no appliance plugged into this receptacle location at the time of the fire. Thus, a problem related to an appliance power cord, or a high resistance connection between the plug and receptacle could be eliminated as possible causes of the fire. The mechanism for the fire clearly had to be some form of resistance heating across the face of the receptacle. The presence of salt crystals on the housing indicated that the most probable scenario was an accumulation of salt crystals creating a resistive path between the hot and neutral locations of the receptacle. This led to resistive heating that charred the plastic housing.

A review of web sites for several manufacturers of outlet strips noted a warning not to use the strips with aquariums. Since there are rarely only two (2) appliances used in conjunction with an aquarium, some method must be used to provide more than the two receptacle locations provided by a standard duplex receptacle. In most instances, the answer that the aquarium user adopts is to use an outlet strip.

When examining aquarium components that have been involved in a fire loss, the issue of salt creep must be considered when dealing with a salt water aquarium. If the component that is believed to have caused the fire is too damaged for a thorough analysis, look backwards on power cords and other items near the origin to determine if salt crystals are present. If they are, the issue of salt creep induced electrical heating must be considered as one possible mechanism for the fire.



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LEGAL ANALYSIS

In the San Diego case noted previously, the plaintiff's theory was improper maintenance by the defendant's tank maintenance company created a condition, which ultimately resulted in the fire. The tank maintenance employee admitted he never checked the electrical components installed by his company for the effects of salt creep/salt trails. The salt trails existed on the tank's outside back panels even after the last service before the fire. There was no preventative maintenance on the tank components. Tank components were replaced only when they failed. The maintenance company did not keep track of the number of hours on the tank components. There was no preventive electrical maintenance or inspection performed by the defendant. Catastrophic failure of tank components caused replacement of electrical components. There was no proactive replacement of electrical components prior to their failure for the aquarium.

Those omissions formed the basis of the negligence claim against the tank maintenance company. Due to the defendant's failure to preserve its own records, exact component manufacturers could not be identified.

CONCLUSION

The National Electrical Code recognizes deteriorating agents can cause insulation failures. Insulation failure of electrical tank components can provide a mechanism to start an aquarium fire. The example analysis noted above shows salt creep occurs. Careful analysis of aquarium components is necessary to determine if they caused the fire or were damaged by the fire starting somewhere else. The effects of salt creep/salt spray should be carefully evaluated in aquarium fire cases.

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(Footnotes)

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2 Chris Bloom is a certified Fire and Explosion Investigator with CJB Fire Consultants, Grant Pass, Oregon.

3 http://www/shop.petsmart.com for the article titled "Choosing Your Aquarium"

4 NFPA 921 – Guide for Fire and Explosion Investigators (2004 Edition), section 11.3.5.5.1.

5 San Diego Fire Department Metro Arson Strike Team Report, Incident Report No. F501-15887. Fire investigator for the City of San Diego Fire

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