The dangers and effects of Smoke, Soot, Moisture and Mould following fire

Smoke is the result of incomplete combustion, which produces tiny particles of carbon in the air. Smoke is a complex mixture of different gases and particles, which results from the various materials that burn during a fire event. A typical structure fire (residential home or business) may involve the destruction of plastics, foams, fabrics, carpets, wood products, synthetic fabrics, wool, and asbestos-containing materials. Respiratory hazards connected with exposures when working in an environment that has been sullied by a fire event differ from those from the past, because the materials that our belongings are made from have changed over the years. For example, plastics and other synthetics are much more prevalent in our homes and studios today. It is important to recognize that these materials undergo pyrolysis (a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen which involves the simultaneous change of chemical composition and physical phase, and is irreversible) during a fire and become the deposits that are identified as soot.

Soot includes the fine black particles, chiefly composed of carbon, produced by incomplete combustion of coal, oil, wood, or other fuels. Soot can consist of acids, chemicals, metals, soils, and dust. The particle size of soot on a surface can present a respiratory hazard. Particles are approximately 2.5 microns, a size that is associated with deep lung penetration. Particles larger than 10 microns get trapped in the upper respiratory tract. Particles that are smaller than 5 microns can make it down to the lower lung where the gas exchange occurs in the alveoli. In order to offer some perspective on the size of these particles, the dust you see flying in the light coming through a window is about 40 microns in size. Airborne soot present within the breathing zone of workers is too small to be seen with the naked eye and can easily be inhaled.

In addition to direct damage due to elevated temperature and heat from fires, non – thermal damage to equipment exposed to smoke and combustion gases from the fire environment can occur (Peacock et.al, 2012). Soot adheres to walls or any other surfaces that are cooler than the heart of the fire. Soot is acidic and therefore destructive to most elements. Over time, acidity continues to degrade most metals by etching and oxidising which can lead to discolouration, pitting or corrosion. When combined with water or high humidity conditions, the acidic strength is exponentially increased and thus the damage is very aggressive. However, controlling humidity and climate may reduce acidic corrosion. Acidic soot residues have ongoing reactions until they are removed (http://www.er-emergency.com/the-effects-of-fire-and-smoke-damage).

Therefore, fire and smoke pose physical and chemical threats to all technical equipment including electronics, machinery, and specialty equipment of all types. Electronic devices are now being used under service conditions that were not considered years ago. This more frequent use and dependence on electronic goods such as mobile phones and laptop computers and other devices has increased the demand for both their reliability and a decrease in size. The reduced spacing between components on a printed circuit board (PCB) due to miniaturization of the device, is a factor that has made it easy for interaction of components in corrosive environments (including post fire environments with the increase of soot, contaminants and moisture). The reduction in size and distance of components makes the system more susceptible to corrosion problems. Even a small environmental impact can cause huge damages if the components are not well protected.

Smoke is magnetically charged and contains metals which act as a path to short circuits and as insulators causing overheating of components. Of the four modes of failure that can occur due to smoke damage as reported following Nuclear Regulatory Commission (NRC) testing (EPRI/NRC-RES, 2005), only circuit bridging has been found to be potentially risk significant (Peacock et.al, 2012). Even light smoke damage has the capacity to short out electronics by bridging circuits and providing an insulating covering on the heat producing components, making them prone to extreme overheating eventually leading to premature failure.
Smoke is very corrosive and reactive it causes pitting and oxidizing corrosion. The typical fire produces the rapid oxidation of a material in the chemical process called combustion. This reaction releases heat, light and various reaction products. This is commonly called the fire tetrahedron. This reaction is very destructive and produces many elemental and chemical by-products. Contaminates must be neutralized to avoid rapid degradation of metals and manmade composite materials (http://www.er-emergency.com/the-effects-of-fire-and-smoke-damage).

A critical factor in the performance and reliability of Electronic power supplies is the purity of the operating environment and cooling air. Even environments considered ‘clean’ contain dust, soot, gasses and salt. Additionally varying levels of humidity and condensation must be taken into consideration, both alone and in combination with contaminants (Cirolia and Finan, 2001). The flow of air may be greatly impeded by the build-up of contaminants. Above a certain critical humidity, electrochemical corrosion can occur, and is stimulated by gaseous and solid atmospheric contaminants such as sulphur dioxide and soot. Corrosion may be the cause of malfunction or failure, and corrosion products which possess some conductivity can be responsible for short-circuits (Bowcott & Cleaver 1961). Non-thermal effects (such as corrosion) may occur over long time periods and therefore impact restoration following a fire incident. For example Patton (1991) reported that corrosion several

days after a one hour fire exposure can be several times that initially observed after the exposure (Peacock et.al, 2012).

Water molecules and contaminant ions ingression into hermetic materials cause significant effects of the performance of electronic devices. Water molecules connect the copper tracks by ECM mechanism, consequently causing failure or unexpected functions to occur. Water molecules may also increase the dielectric constant of substrate materials requiring a higher energy to transmit signals (Khoshnaw, 2010). The presence of particulates and moisture can result in leakage currents sufficient to blow a fuse in the device (Peacock et.al, 2012).

Failure of electronic apparatus under conditions of high humidity and temperatures conducive to the growth of moulds has been noticed. Mould growth exerts a marked deteriorating effect on the surface resistance of extruded insulations. Such mould growth may never be visible to the unaided eye. Moisture and mould may affect the selectivity and sensitivity of some electronic equipment, particularly in the audio-range (Luce & Mathes, N.d). The healthcare industry mandates testing for bio medical equipment for currents and improper grounding. Other types of machinery not properly processed can result in a future fire or electrocution hazard especially if soot is left untreated or internally left wet.

The water used by firefighters to extinguish the fire creates the perfect environment for mould growth. While some types of mould growth aren't particularly noxious, others – known as "black mould" – can release spores into the air that are dangerous. Hidden mould can cause health issues, even to the seemingly healthy individual. The mould spores, whether dormant or dead can trigger allergic reactions to persons with weak immune systems. Constant exposure to mould can also cause allergies to develop over time (http://www.noflood4me.com/mold-removal-after-a-fire.html). These spores can cause nausea, headaches and severe respiratory problems, particularly in children, the elderly and people with compromised immune systems. Your pets can also be susceptible to health problems associated with the proliferation of black mould. Once mould begins to flourish, it can be extremely difficult to remove completely (http://www.alladinrestoration.com/mold-remediation/after-the-fire-the-hidden-dangers-of-post-fire-water-damage).

It is believed that black mould may be responsible for cases of sudden infant death syndrome or Cot death (New Scientist 1997). In 1944, Doctors at case Western Reserve University in Cleveland noticed a number of babies dying from pulmonary haemosiderosis – bleeding of the lungs – with no known cause. They discovered that the growth of black mould Stachybotrys atra in houses might be responsible. Dearborn (New Scientist 1997) believes that the inhalation of the black mould spores, which contain mycotoxins called Trichthecene can inhibit the production of proteins. In babies whose lungs are growing rapidly, reduction in protein synthesis

may result in blood vessels lining the lungs becoming unusually fragile, exposure to other indoor pollutants such as cigarette smoke can cause these capillaries to break (New Scientist 1997, cited in Singh, N.D).

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