Newtron Group

# Equipment Restoration Handbook.

A comprehensive equipment recovery guide designed for property insurance professionals.

# Notes

# Introduction

This handbook was designed to be an introduction and technical reference for loss-related contamination and corrosion to equipment, damage assessment, and restoration. It is also a support tool for professionals in the property insurance and restoration industries.

Chapters 1 through 4 are intended as a primer or refresher, containing a higher level but less technical overview. Chapters 5 and 6 contain more in-depth and technical information, and then Chapters 7 through 10 focus on best in class equipment restoration solutions.

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# Table of Contents


**Chapter 1** Equipment Restoration: Loss Reduction & Control

**Chapter 2** Corrosion in Equipment & Electronics. Cleaning & Restoration Explained

- Smoke Contamination
- Decontamination & Restoration Process
- Water Damage & Moisture Concerns

**Chapter 3** The Benefits of Restoration Vs. Replacement

**Chapter 4** Equipment Restoration Process - Start to Finish

**Chapter 5** Fire Effects on Electrical & Electronic Equipment

**Chapter 6** Equipment & Electronics Corrosion Caused by Moisture & Contamination

**Chapter 7** Solution Overview for Insurance Customers

**Chapter 8** Technical Restoration Procedures

**Chapter 9** Types of Equipment & Electronics that can be Cleaned & Restored

**Chapter 10** Equipment Restoration Warranty Policies – What to Expect from Your Vendor

# Chapter 1

## Equipment Restoration: Loss Reduction & Control

Here is a look at equipment restoration and its effects on a sample of Canadian claims.

Information presented here is a statistical review of financial data collected by Newtron Group over a period of five years, from a number of major commercial equipment losses.

The data shows that in most cases, equipment restoration saved 70% or more in claim amount, in comparison to the cost of replacement. That savings figure does not include the further potential savings on reduced business interruption time.

The question therefore becomes “How do we ingrain this thinking into the claims handling process for every level of claim adjusting staff, from the onset of each claim?”

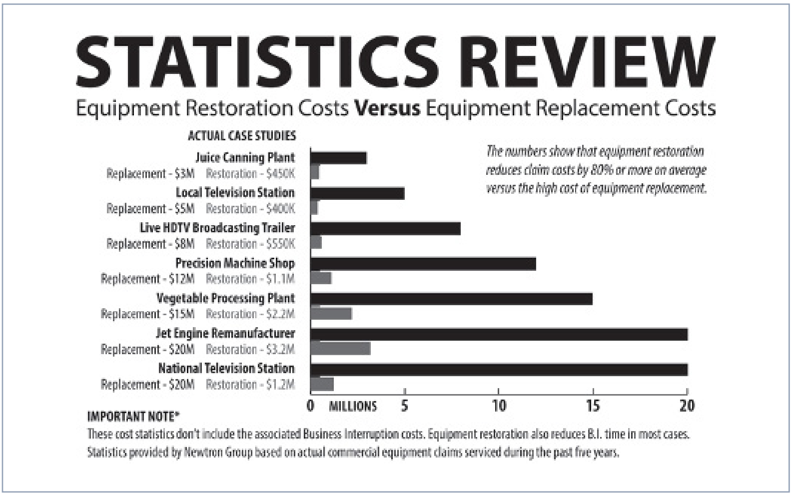
If the potential cost savings are better understood and the ability to realize those savings is ingrained in claims handling, the claims costs will reflect those efforts.

Newtron Group has provided the data to support the fact that restoration of equipment can drive direct claims cost savings.

The following graph shows data derived from actual claims. The savings demonstrated are in millions of dollars and again, these numbers don’t include business interruption losses.

History has shown us that restoration is the most cost and time efficient claims solution. Equipment and technology can be returned and used seamlessly, without concerns caused by compatibility issues or new technology training.

Restoration also supports sustainability measures by keeping equipment out of landfills, as well as reducing shipping and packaging that would have been used for replacement items.

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# Chapter 2

## Corrosion in Equipment & Electronics. Cleaning & Restoration Explained in Plain Language

### Smoke Contamination:

Smoke is the end product of combustion. Its composition varies greatly depending on the material that combusted.

The black soot that gives smoke its distinctive colour is often carbon. It is produced from the burning of wood, plastic, petroleum, and other organic products.

As carbon conducts electricity, it can cause short circuits in electrical and electronic equipment. Furthermore, it can cause overheating problems in heat producing equipment because of carbon's heat-insulating properties.

Carbon does not dissolve in water or solvents, and must be removed by mechanical means such as wiping, scrubbing and vacuuming.

Sulphate and nitrate are contaminants that are also commonly found in smoke. They are produced from the burning of rubber, lacquer paint, petroleum based lubricants, and fuel oil including diesel fuels. Combined with moisture, sulphate and nitrate can turn into various forms of sulphurous and nitrous acids.

These acids can cause serious corrosion in metals and electrical contacts, and the corrosive action can accelerate many orders of magnitude upon the application of electricity.

The most harmful substance often found in smoke is chloride. In a majority of fire losses chloride is produced by the combustion of PVC plastic, which is commonly used in electrical wires, as well as plastic sheets, pipes, and containers.

Chloride reacts readily with moisture and turns into various forms of highly corrosive hydrochloric and hydrochlorous acids. In a typical fire scene, the bright orange flash rust found on bare metal surfaces, and the yellowing of enamel finish on appliances, are their signatures.

One particularly difficult situation is when chloride contacts the surface of ordinary stainless steel such as the 304 type which is one of the most commonly used.

Chloride, in the presence of moisture, can set up tiny galvanic cells on stainless steel surface on locations where there are microscopic mechanical imperfections that breach the micron-thick surface layer.

Such galvanic cells can dissolve away the metal and create cavities below the surface. An even more troubling fact is that the chloride ions that take part in making the metal disappear actually regenerate themselves as the reaction goes on.

Their actions continue indefinitely and make the cavities bigger and bigger. The end result is pitting corrosion that not only tarnishes the appearance - it can eventually cause structural cracking that leads to equipment failure.

Similar problems can occur in the case of chemical contaminations such as the release of acid vapours or fumes, or chlorine gas, and the discharge of chemicals including dry powders from fire extinguishers. It is the water soluble components in the contaminants that react with moisture to cause corrosion problems.

## Water Damage & Moisture Concerns:

Water damage, other than by direct absorption, is often caused by the same substances that make water conduct electricity - the minerals and other deposits that are in it.

Tap water carries a certain amount of minerals such as calcium, sodium, and magnesium, originating from mineral latent rocks buried deep underground in the water table.

Rain water typically contains weak carbonic acid which originates from carbon dioxide dissolving in rain drops as they fall from the sky. It can also contain more harmful acids from pollutants - such as sulphur dioxide and nitrous oxides – that are commonly found in polluted air.

When rain water enters the ground, all the acids and pollutants enter with it and react with whatever minerals they encounter. When it reaches the water table then re-emerges, it contains a lot more than just H2O.

In addition, when that water passes through pumping stations, storage tanks, and pipelines, it picks up different types of metal along the way.

The longer it remains in pipes, pumps, and storage tanks, the more metals it picks up. By the time the water from a broken pipe reaches the equipment, it often carries many surprises.

The most harmful deed water can do is to introduce acids, minerals, and dirt into the equipment. In the presence of water, such contaminants will break down into various ions and start to corrode as soon as they make contact.

If the equipment is energized by electricity while it is still wet, the ions released by the minerals will act as conductors and cause short circuits.

More seriously, the corrosion process can accelerate by many orders of magnitude upon the application of electricity by way of electrolysis actions. Catastrophic failures can occur within minutes or seconds of flipping the switch.

After the water dries, those ions will re-combine into mineral molecules and will stay behind and remain inert. If they are not removed, they will slowly react with moisture in the air, re- activate, continue to corrode and eventually cause the equipment to fail.

Moisture exposure is a costly, and often, an overlooked hazard to electronic equipment. This is particularly problematic in situations where the equipment had been accumulating dust in the interior due to air convection or mechanical cooling by fans.

When air becomes very humid, dust particles begin to absorb moisture and collapse into a wet, dense mass. If the equipment is switched on, this wet, dense mass can conduct electricity and cause short circuits.

If the moisture is allowed to dry, the caking of collapsed dust particles can act as heat insulation that will not allow the equipment to cool properly, or start to obstruct air flow because of the new denser structures.

This, in turn, may cause overheating and eventually failures even though the equipment had never been in direct contact with water.

## The Decontamination & Restoration Process:

When it comes to saving equipment, the battle is far from lost.  The secret is to deal with the situation before corrosion has a chance to inflict any damage that is significant or permanent.

Since water must be present in order for corrosion to take place, the first step is to make sure the equipment remains powered off and stays dry. Without water or moisture, and without electricity as an accelerant, the entrapped minerals cannot break down into ions and therefore will stay inert.

The next step is to completely remove soot, acids, and dirt as soon as possible. The most effective method is to disassemble the equipment, scrub and clean all the affected parts in specially formulated detergents, neutralize the chloride, sulphate or nitrate if needed. Then, if applicable, thoroughly rinse in distilled or demineralized water, or an organic solvent such as ether.

Don’t be afraid to do this on electronic equipment, as they are essentially composites of non-absorbing materials such as ceramic, plastic, silicon and metal, thus cleaning them with such liquids will not cause any harm.

The rinsing solutions do not leave behind any residue when they dry, therefore the equipment will be contamination free.

The secret is to dry them thoroughly at an elevated temperature with well circulated air for extended periods of time to remove any remaining moisture. Such work should only be handled by trained professionals using specialized equipment.

The procedures involved in dealing with moisture-exposed equipment are very similar to those employed for treating smoke and water related contamination.

The disassembly of the equipment, thorough cleaning, and proper drying are the keys. This work should only be handled by trained professionals, using specialized equipment.

Our many years of experience have shown that the success rate for restoring equipment is consistently better than 90% if undertaken quickly.

The cost of the work is typically less than 30% of the net replacement value of the equipment – that is not counting any secondary cost associated with the loss of use of the equipment.

# Chapter 3

## The Benefits of Restoration Versus Replacement

Damaged or contaminated equipment can cause long-term business interruption. Restoration, instead of replacement, will get a company back into production significantly faster with far less cost.

It will also minimize start up challenges and make staff training to adopt new technologies unnecessary. Finally, considering sustainability and climate change concerns, it simply makes sense to restore equipment whenever possible to cut down on environmental impacts from landfills, packaging, shipping and more.

When fire or water damage happens, an experienced equipment restoration company should be called immediately to ensure that all equipment items are given prompt attention.

If too much time is allowed to pass, corrosion could become irreversible and there may be no hope of reclamation.

Equipment restoration can happen in tandem with property restoration in a way that reduces expenses, and helps the customer/client resume their operations as quickly and seamlessly as possible.

Risk management and insurance professionals should keep equipment restoration top of mind whenever involved in a commercial or industrial loss. Millions of claim cost dollars can be saved, thereby impacting the company's bottom line.

# Chapter 4

## Equipment Restoration Process – Start to Finish

These are the typical steps of the equipment restoration process:

1. An incident occurs and the claimant reports a claim to their insurance company

2. The insurance company dispatches and assigns the appropriate service specialists

3. The equipment restoration firm receives a request to service a new claim assignment

4. The firm contacts the claimant or site manager to schedule an equipment assessment and or pick up time

5. The firm assesses the affected equipment on site or in its lab facility to create a report to recommend whether the affected equipment should be replaced or can be fully restored to pre-loss condition. This assessment report provides the insurance company with an estimate of cost and time to conclusion

6. Written permission from the insurance company and claimant are received by the firm prior to restoration

7. The restoration procedures are executed to restore the equipment to pre-loss condition

8. Restoration technicians test the restored equipment to ensure it functions properly and/or coordinates the appropriate equipment vendors to test and certify the restored equipment

9. If needed, the firm stores the equipment in its secure facility until the claimant is ready for it to be delivered to their property

10. Upon approval by the insurance company and claimant, the equipment is delivered back to the claimant. The restoration firm then gets signoff of successful delivery and receipt of the equipment

11. The firm should provide a 1 year warranty to the claimant for peace of mind upon completion

12. The equipment restoration firm is then paid by the insurance company or property restoration contractor directly

13. HST or GST billed on the claim is the claimant's responsibility to pay, unless the claimant's insurance policy specifically states differently

## Chapter 5

# Fire Effects on Electrical & Electronic Equipment

*Referenced and sourced from the Department of Energy, United States of America, DOE Handbook – Fire Protection – Volume II - Prepared by Hughes Associates, Inc.*

Fires in or around electronics or electrical equipment are a concern due to the large amount of control, communications and data processing tasks performed electronically.

Several electrical fires have resulted in the direct loss of large amounts of capital investment and in the incapacitation of communication systems and business operations. In addition, process control, shutdown and emergency functions related to safe operation of manufacturing, industrial, commercial and energy facilities often rely on electrical and electronic equipment.

The effects of fires on electrical and electronic equipment are significant, causing both short-term and long-term problems.

Short-term effects include short circuits or other electrical malfunction, rendering equipment inoperable or initiating undesired actions. Long-term potential impact includes corrosion and reduced reliability of equipment causing sporadic, unpredictable outages.

# Effects of Fire and Smoke Corrosivity on Electronics Equipment

This section addresses the various mechanisms of damage to electronic equipment as a result of fire. Several major categories have been proposed: heat, smoke corrosivity, and soot deposits.

Arcing as a result of a fire may be caused either by corrosion or water applied through suppression efforts (sprinklers or fire department). Consequently, arcing is not considered a primary damage mechanism.

The three primary damage mechanisms considered in this section are heat damage, corrosion damage, and soot deposition. Suppression effects are not considered.

## Corrosion Damage

The purpose of this section is to review the basic corrosion mechanisms, identify those that would be expected from fire products, identify the fire products that cause corrosion, and finally to list the potential effects of corrosive gas products on electronic components.

Corrosion is the deterioration and destruction of a material due to a reaction with the environment. Corrosion is commonly associated with metals, but also includes plastics, rubber, ceramics, and other non-metallic material.

Electronic components corrode in normal environments, albeit very slowly. Fire environments introduce new and higher concentrations of chemicals and moisture that induce corrosion. Here is more detail on the corrosion of metals with corrosive products found in fire gases.

Corrosion of metals is an electrochemical degradation. This degradation is accelerated when in contact with acids or bases. The products of corrosion are metal oxides and salts.

1. **Pitting Corrosion.**
   This is a localized form of corrosion that results in holes in the metal surface (Fontana, 1986; Skeny et al., 1985). The diameter of the holes is usually small and the depth is equal to or greater than the diameter. Pitting is caused by halide ions, except for fluoride and iodide.

2. **Crevice Corrosion.**

   This type of corrosion is similar to pitting. Crevice corrosion occurs in locations where there is contact between metals and nonmetals that create stagnant pools of the corrosive materials. (HCI and water or other corrosive fire products) (Fontana, 1986).

3. **Uniform Corrosion.**

   This type of corrosion occurs at a uniform rate over the entire surface. This can occur to metals with an even distribution of corrosive gases on the surface. A simple example of this type is a rusting barrel.

4. **Two-Metal·Corrosion.**

   When two dissimilar metals are in contact and in the presence of a corrosive agent, a flow of electrons is induced. The result is the less corrosive resistant metal corrodes faster and the more resistant slower than if they were not in contact.

5. **Stress Corrosion.**

   Stress corrosion occurs when a metal under tensile stress is subject to corrosive agents. The corrosion is accelerated by stress induced cracking, increased tensile stress, larger surface area for corrosive attacks (Fontana, 1986; Sandmann and Widmer, 1986).

## Production of Corrosive Gases in Fire Environments and Generating Materials

There are many corrosive products that can occur in fire environments. Fire products from most burning materials are corrosive to some target.

The rate and quantity of corrosive products generated is as with most fire parameters, governed by material properties and the conditions under which the decomposition or combustion is occurring.

The rate at which corrosive (or toxic) products from a fire are produced is proportional to the mass burning rate of the fire. The mass burning rate is a function of the many variables including fuel type, orientation, oxygen concentration, compartment size, ventilation, etc.

Corrosive products can be thought of as individual gas species (e.g., HCI – Hydrochloric Acid) or as a characteristics of the smoke itself comprising of all the chemical species present and their interactions.

The makeup of the fuel and the process in the flame reaction zone also have an effect on the composition of the corrosive decomposition products. The formulation of the compounds used in products may greatly affect the rate of production of corrosive products.

For example, while two materials may contain equal masses of PVC, the evolutions of HCI will be impacted by the precise nature of fillers, plasticizers, etc. used for a specific product. The chemical composition of the product aside, the nature of the product will of course alter the production rate of corrosive gases.

A flooring material and a cable insulation with nearly identical chemical composition will be expected to result in different corrosive product generation rates, even under identical test conditions.

No discussion of any fire related hazard property of a material is complete without regard for the end-use configuration of a material. The classic example of this problem is a cable insulation used behind a barrier versus one used in open cable runs.

This of course in not a new or unique problem in assessing fire hazard properties of materials, but is one that should not be forgotten.

The evaluation of the hazard posed by the generation of corrosive products should not be done in isolation of other hazard variables (e.g., humidity, temperature, heat flux). This is a classic problem in combustion toxicity hazard assessment. The evaluation of “the hazard” of a material should somehow include all relevant hazard measures, commensurate with the application of the material.

## Corrosive Gases Adversely Affect the Performance of Electronic Equipment in Several Ways.

The following are the most common mechanisms where corrosion causes electronic failure:

1. Corrosion of leads causing shorting, openings, and current leaks,
2. Changes in the overall electrical impedance of a circuit board,
3. Changing of resistors due to decreased area,
4. Relay, switch, and connector contact resistance changes,
5. Disintegration of printed circuit board matrix epoxy resins and
6. Corrosion of cable insulations.

A common corrosive generated in an electrical fire environment is hydrochloric acid (HCl). Others include hydrofluoric acid (HF), hydrobromic acid (HBr), nitric acid (HN03), sulfuric acid (H204), carbolic acid from carbon dioxide, and acetic acid. These products are released to the atmosphere upon combustion.

Table 4 is a partial list of materials that are known to produce corrosive quantities of several gases.

## Table 4. Corrosive and Generating Materials

| Gas | Materials |
|---|---|
| HCl | PVC, Halon Agents |
| $NO_2$ | Nylon, Coal, Kerosene |
| HF | Teflon, Tefzel, Halon Agents |
| HBr | Halon Agents |
| $SO_2$ | Coal, Coke, Oils, Kerosene |

The concentration of corrosive gases in the fire environment is related to the yield of the gas per gram of material combusted. It has been shown that the actual yield is always less than the theoretical yield (Galloway and Hirschler, 1987; 1988; Galloway et al., 1991).

This is because (1) as much as 25 percent of the necessary ions (chloride, sulfur, fluoride) remain in the char, (2) 25 percent or more of the ions will condense in the immediate vicinity of the fire, (3) the corrosive gases are absorbed on soot particles and (4) the gases in the atmosphere decay.

The importance of gas absorption on soot particles was contradictory in the literature (Knowlen, 1990; Galloway and Hirschler, 1990); however, it was clear that this is indeed occurring to some extent. The generation of corrosive gases thus varies widely from material to material.

Currently, there is no comprehensive list of generation rates for particular gases. It should be noted that regardless of the mass content of chloride in a burning substance, several sources indicated that HCl concentrations rarely exceeded

200-300 ppm when measured in actual fire situations (Galloway and Hirschler, 1982; 1989).

## Transport of Corrosive Products

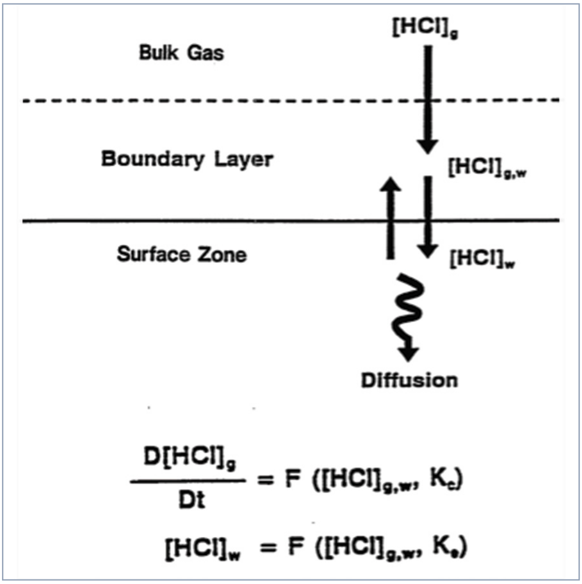
In terms of assessing the impact of the generation of a corrosive smoke, the transport of that smoke to the exposed item(s) of interest is of critical importance. This is due primarily to the potential for adsorption of some important corrosive products on wall and ceiling surfaces.

It is possible to predict transport of CO from a source to a target, the problem is much more complex, but within current capabilities for acid gases.

HCl is illustrative of acid gases. The HCl transport/deposition process can be reduced to three phases: a bulk gas phase, a boundary layer phase, and a surface phase (refer to Figure 7).

The bulk gas phase is essentially the exposure concentration. It is assumed that for a well-mixed compartment that the concentration in this layer is uniform and a function of the generation rate, the mass flow out of the compartment, and the overall deposition rate. HCl is transferred from the bulk gas phase via diffusion into the boundary layer zone.

The boundary layer is a transient zone where the gas and the surface interact. The surface zone is where the HCl diffuses into the material, chemically interacts with the surface material, escapes back into the boundary layer or remains at the surface.




## Figure 7. HCI transport and decay model

There are several key factors that will affect the overall deposition rate and surface concentration of HCI. The most important are as follows:

1. Surface material,
2. Relative humidity,
3. Bulk gas HCI concentration,
4. Boundary layer HCI concentration, and
5. Surface HCI concentration.

The surface on which the decomposition occurs is of great importance when modeling the deposition of corrosive gases.

Materials can have surface characteristics that yield deposition rates two to three orders of magnitude in difference (Jones, 1990). PMMA is a relatively unresponsive surface with respect to HCI whereas copper is almost 1000 times more sorbtive as a result of the chemically interactive surface.

The material parameters also include the ability of the material to diffuse the material through it and the chemical reactivity of the surface. An important example of a material with chemical products that are of concern is zinc exposed to HCI. The final product is ZnCI2 which is extremely powerful desiccant.

The amount of water that ZnCI2 is capable of extracting from the atmosphere both causes the products and contaminants to spread as well as increasing the amount of chloride ions that can be held on the surface (Reagor, 1992).

The relative humidity is also a critical factor in the deposition (and corrosion) process. The higher the humidity, the greater the equilibrium concentration of surface HCI.

It has long been known that the corrosion rate is slowed considerably when the humidity is low. Reclamation and salvaging operations put contaminated electronic equipment in environments with 30 percent relative humidity or less (Galloway et al., 1989).

## Response of Exposed Elements

The response of a target to an exposure of corrosive products is a key element in the evaluation of the "hazard" posed by a material. The response to an exposure (and consequences of that exposure) varies with the target of interest.

Structural steel corrosion poses a different problem than degradation of circuit board material resistivity due to corrosive gas exposure.

The issue of damage caused by corrosion is strongly dependent on other environmental conditions existing at the time of exposure and in the postfire exposure time frame.

During the exposure, the target exists in an environment controlled by the fire. Conditions of temperature and humidity have an effect not only on corrosion induced damage but may cause damage independent of corrosion.

## Environmental Conditions

The environmental conditions, particularly relative humidity, during postfire exposure are critical to the eventual corrosion damage. Postfire damage control procedures typically include moisture/humidity control as a top priority in successful salvage efforts.

Humidity control can be provided by constructing controlled environments around equipment, moving equipment to a controlled humidity environment, or providing humidity controlling equipment in a space.

Non-thermal fire damage is caused by halogenated products such as hydrogen chloride, which is generated primarily from PVC and halogenated fire retardants.

Rapid corrosion occurs when relative humidity is between 70 to 80 percent, and surface chloride concentrations is greater than 91 grams per 9,290 square meters of exposed surface area.

In addition, corrosion occurs when atmospheric concentrations of hydrogen chloride are equal to or greater than 100 ppm, and nitrogen dioxide, acetic acid, hydrogen fluoride and sulfur dioxide are equal to or greater than 1000 ppm.

Hirschler (1990) summarizes the test methods available on smoke corrosivity and their performance to measure the non-thermal damage from fire gases to the electronic and telecommunication equipment and assemblies.

He classified effects of corrosive smoke into three categories: metal loss, bridging of conductor circuits, and formation of non-conducting electrical or electronic circuitry into surfaces on contents.

## Corrosive Effects of HCl

He classified effects of corrosive smoke into three categories: metal loss, bridging of conductor circuits, and formation of non-conducting electrical or electronic circuitry into surfaces on contents.

Corrosive effects of HCl have been quantified in several ways. Standardized tests have been developed that measure mass loss/gain of metals subject to HCl, the change in resistance of both metal coupons and elementary circuits, and the chlorine concentration of the product in question (old method) (Roux, 1993; Pickering, 1985).

In general, companies that specialize in salvaging equipment exposed to corrosive environments use a set of surface chloride ion ranges as guidelines (see Table 7).

## Table 7: Effects of Surface Chloride Ion Concentration on Salvageability

| Range (µg/in2) | Action / Comment |
|---|---|
| < 30 | Normal background |
| 30-200 | Easily reclaimed |
| > 600 | Cost effectiveness of restoration is questionable |

Table 8 lists the threshold airborne concentrations of some common acid forming gases that may produce measurable corrosion damage (Gibbons and Stevens, 1989).

## Table 8. Threshold Airborne Concentrations of Common Acid Forming Gases

| Gas | Acid | Concentration (ppm) |
| --- | --- | --- |
| HCl | HCl | 100 |
| HF | HF | 100 |
| NO2 | HNO2 | 100 |
| NO2 | HNO3 | 100 |
| SO2 | H2SO4 | 1000 |
| CH2COOH | CH3COOH | 1000 |

## Particulate Materials (Soot)

Particulate matter can be damaging to electronic equipment by causing discoloration, mechanical damage, and inducing electrical shorts.

Particulate matter or soot is composed of a number of materials including carbon, resins, tar, and unburnt fuel. The size, distribution and the composition depend on the burning conditions, the material and time.

Typical electronic components that are mechanically damaged by smoke particles are disk drives, uncovered relays, fans, switches, and meters.

In fires, large variations in smoke particle size due to coagulation and condensation, have been found. As the smoke moves away from the fire origin, large particles settle to the floor.

In Figure 13, data for most frequently occurring smoke particle radius reported by Nolan (1989) are plotted against time. In the experiments, mass of particles versus aerodynamic diameter was measured in a 4.53 m3 JP-4 pool fire. The data shows that initially the smoke particles are coarse.

The particle size decreases slowly with time, suggesting that large particles are settling down from the hot layer at the ceiling.

The generation rate of soot can be approximated using yield rates (kg smoke/kg fuel burned). Typical yield rates are on the order of 0.05-0.15 kg/kg of fuel. After the aging characteristics and generation rate is known, the approximate concentration of particulates can be calculated.

Soot, carbon, or other noncorrosive chemicals affect the operation of electrical equipment by changing the conductivity or heat insulation characteristics of the equipment it is deposited upon.

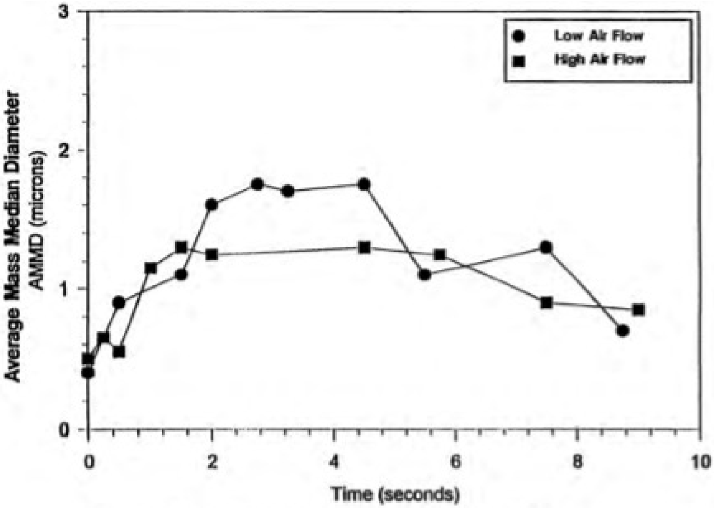



Figure 13. Smoke particle size as a function of time for two airflows (Nolan, 1989)

These contaminants are typically addressed at Total Petroleum Content (TPC). TPC on clean equipment is usually less than 5 µg/in2.

According to Ken Greenough, Ph.D.(1993) of Restoration Technologies Inc., electronic equipment with a TPC exceeding 50-100 µg/in2 can potentially have concerns with conductor resistance, overheating, or corrosion because contaminants can cause base metals to become exposed.

## Reconditioning of Equipment

Restoration and reuse of existing equipment after a disaster typically results in less downtime for training, transfer of data, and start up delays.

Costs for restoration of equipment ranges from 5 to 50% of the replacement costs with manufacturers indicating that typically restoration costs are 20-40 percent.

Damage to equipment may take several forms including heat exposure, soot deposits, corrosion, and water or physical damage from the fire or suppression activities. All of these concerns are potentially addressed by reconditioning services offered by Newtron Group.

## Levels of Contamination and Impacts on Equipment

## Fire Damage

The level of contamination is a function of the type of fire and the location of the equipment with respect to the fire. Reagor (1989) discusses the effects of a fire on electronic equipment based on the fire properties.

Low temperature fires are expected to deposit large accumulations of non-conductive soot. This result is expected based on the incomplete combustion during a low temperature event will produce an assortment of organic compounds.

Reagor lists potential compounds produced include: phthalate esters, acids and anhydrides, low molecular weight alkanes and alkenes, olefins, aromatic fragments, and corrosive hydrogen chloride. Charring, ash, and molten drips are also evident in a low temperature fire.

A high temperature or rapidly growing fire is expected to produce highly conductive soot with low to moderate particulate accumulation (Reagor, 1989). Large amounts of corrosive gases are possible as well as significant thermal damage to equipment.

Criteria have been established as to how and when electronics or electronic equipment can be salvaged or reconditioned based on the exposure levels to the fire effects.

After a fire incident, the level and types of contaminants must be determined (Reagor and interviews). Fire effects can include water and dirt residues, heat deformation, electrical damage as well as soot or chloride or other halogen acid contamination levels exceeding 5000 µg/in2.

## Impact of Water, Heat and Corrosives on Equipment

Electronic equipment exposed to water damage can be restored or reconditioned in some circumstances. If water is applied to the equipment to put out the fire prior to removal of power, the equipment will most likely need to be replaced (Reagor, 1989).

If equipment has been deenergized prior to the application of water, drying of the equipment is necessary as a minimum. If the water leaves a residue that creates electric conductivity, this residue will also require removal.

Exposure of electronic equipment to heat typically causes permanent damage. Significant damage can occur at exposures of 175'P (79°C), and malfunction can occur at 140°F (60°C) (Factory Mutual, 1993).

Damage caused by heat can be related directly to the material properties of the exposed equipment. Reconditioning services typically attempt to repair electronic equipment with the limits of visible thermal damage confined only to the enclosure cabinet.

Thermal damage to circuit boards, cables, or other internal portions of the equipment result in the equipment being irreparable. Parts of electronic equipment that have visible or electrical damage caused by heat are generally replaced.

The levels of contamination by corrosives affects the viability of repairing the equipment. Several sources discuss contamination levels and renovation possibilities (Reagor, 1992).

All of the publish sources provide information based on chloride equivalent contamination levels. Clean equipment is anticipated to have contaminates of 10 µg/in2 or less.

Chloride levels of 30 to 60 µg/in2 are typical of ambient exposures over a twenty-year period.

After exposure to a fire involving halogenated materials contamination levels from 30 to 6000 µg/in2 are possible. Table 9 from Factory Mutual Research Corporation provides a summary of contamination levels and the potential effects on metal surfaces and electronics, based on an exposing environment.

This level of contamination can then be converted to a probability (p) of device failure based on the exposure using the following equation:

$$P = 1 - e^{-[(C-3) / Co]}$$

where C = surface concentration of smoke particles in µg/cm2, and Co = average surface concentration of smoke particles causing damage, in µg/cm2 (determined from surface testing).

## Table 9. Contamination Exposures and Effects

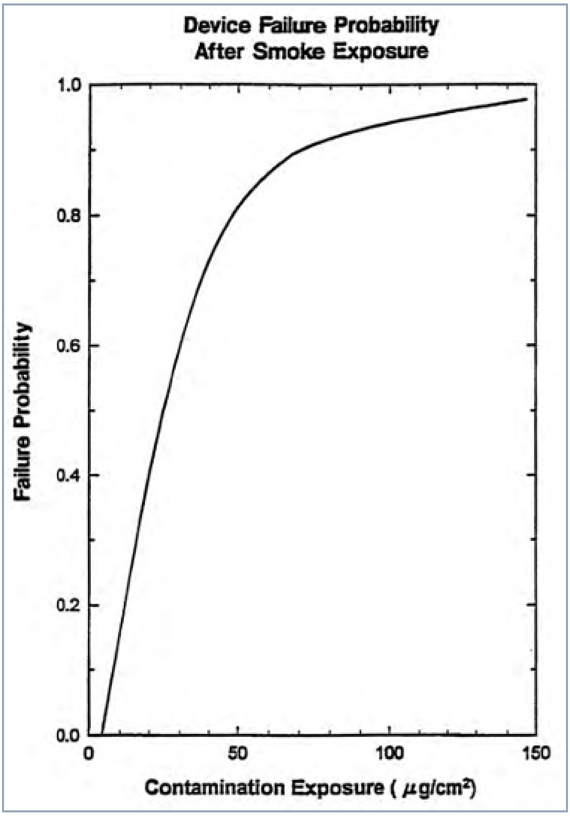
| Contamination Level | | Ambient Conditions | Effects | |
|---|---|---|---|---|
| µg/cm² | µg/in.² | Typical Environment | Metal SFC | Electronics |
| Above 77 | Above 500 | Very reactive Rh>50% Hot plastics fire Seawater spray | Flash rust Etched surfaces | Heavy corrosion Catastrophic failures |
| Above 30 | Above 200 | Reactive Rh>60% Medium to heavy smoke | Light rust Long term | Active corrosion Short term |
| Above 16 | Above 100 | Factory environment Rh 30-90% - uncontrolled | Light rust Long term | Moderate corrosion Long term |

*Continued on next page*

| | | | | |
|---|---|---|---|---|
| Above 8 | Above 50 | Controlled environment Rh 45-55% T65-75°F | None | Slight surface corrosion Long term |
| Above 3 | Above 20 | MIL STD SPEC High reliability | None | None |

The probability of a device failure based on contamination levels is identified in Figure 14. The goal of reconditioning equipment is to reduce surface contaminants to an acceptable level and return the equipment to a functional state.

## Figure 14. Device Failure Probability After Smoke Deposition




*Referenced and sourced from the Department of Energy, United States of America, DOE Handbook – Fire Protection – Volume II - Prepared by Hughes Associates, Inc.*

# Chapter 6

## Equipment & Electronics Corrosion Caused by Moisture & Contamination

*Referenced and sourced from the Guidelines for Handling Water-damaged Electrical Equipment published by the National Electrical Manufacturers Association.*

Electrical equipment exposed to water can be extremely dangerous if re-energized without proper reconditioning or replacement. Impacts on electrical insulation from moisture, debris lodged in equipment components, and other factors can affect the ability to perform its intended functions.

Damage to electrical equipment can also result from flood waters contaminated with chemicals, sewage, oil, and other debris that affect its integrity and performance. Ocean water and salt spray can be particularly damaging due to the corrosive and conductive nature of the salt water residue.

After consultation with the manufacturer, some types of electrical equipment may be reconditioned by properly trained personnel. The ability to recondition the equipment will vary with the nature of the electrical function, the degree of damage, the age of the equipment, and the length of time the equipment was exposed to water.

### Electrical Distribution Equipment

Electrical distribution equipment usually involves switches and low-voltage protective components. This includes: molded case circuit breakers and fuses within assemblies, such as enclosures, panelboards, and switchboards.

These assemblies can be connected to electrical distribution systems using various wiring methods.

The protective components are critical to the safe operation of distribution circuits. Their ability to protect these circuits is adversely affected by exposure to water and to the minerals and particles which may be present in the water.

In molded case circuit breakers and switches, such exposure can affect the overall operation of the mechanism through corrosion, the presence of foreign particles, and the removal of lubricants.

The condition of the contacts can be affected and the dielectric insulation capabilities of internal materials can be reduced.

Further, some molded case circuit breakers are equipped with electronic trip units whose functioning might be impaired. For fuses, the water may damage the filler material, which will degrade the insulation and interruption capabilities.

Distribution assemblies contain protective components together with the necessary support structures, bus work, wiring, electromechanical or electronic relays and meters. Exposure to water can cause corrosion and insulation damage to all of these areas.

## Motor Circuits

Motor circuits include motor starters and contactors, together with overcurrent protection components such as overload relays, circuit breakers, and fuses.

These are often assembled into motor control panels and motor control centers as well as individual enclosures. Motor control centers contain both control and protective components, with support structures, bus work, and wiring.

These protective components are critical to the safe operation of motor circuits. Their ability to protect these circuits is adversely affected by exposure to water, and to the minerals and particles which may be present in the water.

For molded case circuit breakers, such exposure can affect the overall operation of the mechanism through corrosion, foreign particles, and through removal of lubricants.

The condition of the contacts can be affected and the dielectric insulation capabilities of internal materials can be reduced. Further, some molded case circuit breakers are equipped with electronic trip units, whose functioning may also be impaired.

For fuses, the water may affect the filler material. A damaged filler material will degrade the insulation and interruption capabilities.

Corrosion, loss of lubrication, and insulation quality can also be expected in contactors and starters. However, solid-state motor controllers and those electromechanical contactors or starters with integral electronic circuitry will be more severely affected by water.

## Power Equipment

Power equipment involves low voltage or medium voltage protective devices within an overall switchgear assembly. The assembly may also contain cabling, buswork with appropriate insulators, current transformers, electromechanical or electronic relays, and metering.

Reliable operation of the protective devices is vital to system safety; however, these devices can be adversely affected by water.

In the case of low voltage and medium voltage circuit breakers and switches, the operation of the mechanism can be impaired by corrosion, particles such as silt, and by the removal of lubricants.

The dielectric properties of insulation materials and insulators will degrade and, for air circuit breakers, the condition of the contacts can be affected.

Further, low voltage power circuit breakers usually incorporate electronic trip units; the functioning of these units will be impaired, as can the functionality of electronic protective relays and meters.

Power circuit breakers and medium voltage breakers are designed to be maintainable with the possibility, for example, of replacing contacts in air circuit breakers.

It may, therefore, be possible to reuse such breakers provided the refurbishing is performed in close consultation with the manufacturer. This would include cleaning and drying techniques, lubrication advice, and thorough testing prior to the reapplication of power.

In all cases, great attention must be paid to the thorough cleaning, drying, and testing of insulators and insulation material.

## Restoration of Power Equipment:

At Newtron Group, we consult the manufacturer on the correct selection of cleaning agents which remove impurities without damaging the conformal coating.

The manufacturer must also be contacted relative to the exact testing required of sophisticated electronic equipment containing, for example, microprocessors.

The overall power equipment assembly (switchgear) may be able to be reconditioned provided careful steps are taken in the cleaning, drying, and testing of the equipment prior to applying power.

An area of particular concern is the maintenance of the dielectric properties of insulation.

In the field application of medium voltage equipment, for example, standoff insulators are subjected to a wide variety of high voltage surges. Such insulators might need replacement.

## Transformers

Exposure to water can cause corrosion and insulation damage to the transformer core and winding.

The ability of the transformer to perform its intended function in a safe manner can also be impaired by debris and chemicals which may be deposited inside the transformer during a flood. Water and contaminates also can damage transformer fluids.

## Wire, Cable, and Flexible Cords

When a wire or cable product is exposed to water, any metallic component (such as the conductor, metallic shield, or armor) is subject to corrosion that can damage the component itself and/or cause termination failures.

If water remains in medium voltage cable, it could accelerate insulation deterioration, causing premature failure. Wire and cable that is listed for only dry locations may become a shock hazard, when energized, after being exposed to water.

## Wiring Devices, Ground Fault Circuit Interrupters (GFCI), and Surge Protectors

Sediments and contaminants contained in water may find their way into the internal components of installed electrical products and may remain there even after the products have been dried or washed by the user.

These may adversely affect the performance of those products without being readily apparent. GFCIs and surge protective devices can be adversely affected by water resulting in the device becoming non-functional or a hazard to the user.

## Motors

Motors which have been flooded by water may be subjected to damage by debris or pollutants. This may result in damage to insulation, switches, contacts of switches, capacitors and overload protectors, corrosion of metallic parts, and contamination of the lubricating means and should be evaluated by qualified personnel.

The manufacturer should be contacted for specific instructions on possible disassembly, cleaning, and drying of the motor housing and internal components by trained personnel.

## Electronic Products, Including Signaling, Protection, Communication Systems, and Industrial Controls

Equipment used in signaling, protection, and communication systems generally contain electronic components, and the exposure of such equipment to flooding by water can adversely affect the reliability of those systems.

Contamination by pollutants or debris in flood waters may cause corrosion of components of the system, shorting of printed circuits, or alteration of circuit characteristics.

Since some of these types of installations are classified as life safety systems, it is important that the reliability of those systems be maintained.

Where such systems are damaged by water, it is recommended that components of these systems be replaced or restored with the appropriate cleaning, recalibration, and testing.

Manufacturers of these systems should be contacted for information on specific equipment by the restoration firm.

*Referenced and sourced from the Guidelines for Handling Water-damaged Electrical Equipment published by the National Electrical Manufacturers Association.*

# Chapter 7

## Solution Overview for Insurance Customers

When equipment has been affected by fire, moisture or smoke, and it is given to Newtron Group, it is in the best hands available, once equipment is deemed to be restorable.

Newtron Group's team of highly experienced and equipped technicians are fully bonded, trained and qualified to professionally service affected items. They will remove corrosion, decontaminate, clean and restore even the most sensitive electronics, machinery, and equipment of high technology.

Newtron Group has had tens of thousands of extremely satisfied customers all across Canada since opening their doors in 1996.

This includes hospitals, scientific and research labs, nuclear facilities, doctors, dentists, manufacturing plants, radio and TV broadcast studios, aerospace facilities and numerous other industries. Also included in this list are the electronics and appliances restored from residential losses caused by fires and floods.

Newtron Group is trusted by dozens of respected insurance companies nationwide, including but not limited to Zurich, Intact, Aviva, AIG, Allianz Global, RSA, Travelers, FM Global and many more.

They are also called into action by independent adjusting firms such as SCM Claimspro., Charles Taylor Adjusting, Sedgwick and McLarens, and Crawford Canada. In addition, they provide services through property restoration companies such as Winmar, ServiceMaster, Belfor Canada, First Onsite, On Side and First General.

If you have experienced an equipment loss, you are most likely facing a great deal of stress and have concerns about your equipment and technology.

Take comfort in knowing that Newtron Group is trusted to produce extraordinary results, quickly and efficiently for equipment claims of all sizes. Their clients also appreciate the value of their one-year warranty on their work that guarantees pre-loss condition of serviced equipment.

## What is Newtron Group Equipment Restoration, Cleaning & Consulting?

Newtron Group is Canada's leading, full service equipment and electronics restoration, cleaning and consulting firm servicing the insurance industry since 1996. Newtron Group is available 24 hours a day every day of the year to support claims nation-wide.

They operate out of the largest (over 50,000 sq ft) and most advanced equipment restoration facility in Canada, located at 8 Indell Lane in Brampton, Ontario.

Newtron Group's goal is to assist clients in achieving the best possible claim resolutions by providing accurate information and recommending cost-effective options and solutions.

Their services enable clients to handle their claims fairly, efficiently and in a timely manner. This means that the insured gets their equipment back quickly in a condition equal to or even cleaner than the moment prior to the incident.

Newtron Group aims to reduce equipment use interruption time so insured customers can get back to their daily life and operations quickly.

## Service Overview and Summary

When a new assignment is received, Newtron Group will make arrangements to inspect the insured's equipment as soon as possible to determine if decontamination is required. Speed is of the essence because if too much time has passed, the equipment may corrode so severely that it cannot be restored.

Newtron Group's Restoration Services' proprietary chemical processes have been proven effective in neutralizing contaminants and removing corrosion caused by water and smoke in consumer electronics, industrial equipment, advanced commercial electronics, manufacturing machinery, and enterprise level computer technology.

Depending on the urgency of the assignment, Newtron Group can either go ahead with a rush decontamination of restorable items or test each item and provide a detailed report to their client. As a courtesy, Newtron Group also provides approximate replacement costs for all the written off items included in their reports.

## Technical Consulting

In cases where repairs are required, Newtron Group's technical staff are able to coordinate efforts with outside vendors to conduct repairs and replace damaged components.

They can be extremely effective to serve as technical project managers or monitors on large losses that require in depth understanding of electrical, mechanical and technological systems.

# Chapter 8

## Technical Restoration Procedures

Newtron Group employs proprietary chemical processes that have been proven effective in neutralizing contaminants and removing corrosion caused by water and smoke affecting industrial equipment, computer hardware and electronics.

These processed involve a combination of procedures called Modified Dry, Modified Wet and Full Wet.

The decision regarding which procedure to use on a particular piece of equipment is made by the Project Manager and/or the Site Supervisor, based on factors including but not limited to the circumstances of the loss, the type of equipment, and the condition of the equipment.

Newtron Group's restoration process often requires partial or full disassembly of the device being worked on. For the Modified Wet and Full Wet procedures, selected groups of specialized chemicals (environmentally safe and designed not to harm or have any adverse long term effects on equipment), are utilized.

As well, Newtron Group is committed to following all Electrostatic Discharge procedures and our team members are equipped with all the necessary ESD protective equipment.

### Procedure options when Newtron Group undertakes a restoration project:

1. **Modified Dry Procedure**
   The Modified Dry process is utilized when equipment has very light contamination and/or when an item cannot be safely exposed to wet processes due to sensitive components such as optical circuits, relays, and wicking components.

2. **Modified Wet Procedure**

   Items that have light to medium contamination and can be exposed to wet processes are ideal candidates for the Modified Wet Procedure.

3. **Full Wet Procedure**

   The Full Wet process is used for equipment that has medium to high levels of contamination and can be fully exposed to wet processes. Interestingly, the same Full Wet process is also utilized by circuit board manufacturers in the final stages of production to remove excess solder, flux, and other particulates.

# Chapter 9

## Types of Equipment & Electronics that can be Cleaned & Restored

### Musical Systems

- Organs
- Electronic Pianos
- Synthesizers
- Mixer Boards
- Special Effect Equipment
- Stage & Light Controls

### Medical Equipment

- CT & MRI Scanners
- X-ray, Ultrasound & Mammography
- Nuclear Imaging
- Radiation Treatment Equipment
- Dental Chairs & Equipment
- Dental Lab Equipment

### Fire & Security Equipment

- Security Alarms
- Intercom Systems
- Fire Alarm Panels
- Surveillance Equipment

### Office Equipment

- Photocopiers, Fax & Scanning Equipment
- Conference Room Equipment
- Mailroom Equipment

### Hvac & Environmental

- Air Conditioners
- Heat Pumps
- Energy Management & Control
- Computerized Smart Home Control

### Semi-Conductor Manufacturing

- Wafer & Chip Manufacturing
- Circuit Board Making
- Automatic Insertion Equipment
- Testing & Quality Control

### Broadcasting

- Transmitters & Antennae
- Cameras & Recorders
- Studio & Mobil Equipment
- Audio/Video Editing Equipment
- Data Transmission Equipment

### Satellite & Communications

- Cellular & Land Line Switching Stations
- Satellite Tracking and Relay Stations
- Voice & Data Switches
- Microwave Transceivers

## Printing Equipment

- Multicolour Printing Presses
- Graphic Systems
- Typesetting & Layout Equipment
- Plate Making Equipment
- Digital Printing & Photocopying Equipment

## Computers

- Mainframes & Servers
- Data Storage & Backup
- Networking Equipment
- Professional Workstations
- Input / Output, Imaging & Peripheral Equipment
- Personal Systems

## Manufacturing

- CNC Machines
- Robots & Automatic Control
- Processes Control Equipment
- EDM Machines
- CAD/CAM Terminals
- Production Line Machinery
- Injection Moulding & Die Cast Machines
- Data Acquisition & Logging Equipment

## Telephone Systems

- KSU
- PBX
- Voicemail System
- Switchboards
- Voice & Data Transmission Equipment

## Laboratory

- Mass Spectrometers
- Electronic Microscopes
- Gas & Liquid Chromatography
- Precision Measuring Equipment
- Test Instrument
- Sampling Handling Equipment
- Data Recording Equipment

## Financial Institutions

- Banking Equipment
- Micro Film & Fiche
- ATM
- POS (Point-of-Sale)
- Data Communications Equipment

## Food Processing

- Food Manufacturing equipment
- Processing Plant & Line equipment

Newtron Group is capable of responding to any emergency situations nationwide by dispatching trained, experienced professionals in computer & electronics, industrial equipment, and cause & origin investigations.

By working on site with adjusters, the insured, and the contractor, they provide the most cost-effective courses of action to minimize business interruption, maximize efficiency, and ensure customer satisfaction.

# Chapter 10

## Equipment Restoration Warranty Policies – What to Expect from Your Vendor

When an equipment restoration firm restores technological equipment they should be able to stand behind their workmanship by providing a warranty on their service and results.

Ideally, this would be an industry standard and be required to ensure both the insurance company and claimant that the equipment is trustworthy. Here is an example of Newtron Group's standard warranty policy.

### Electronic Products, Including Signaling, Protection, Communication

### Level of cleanliness

We warrant that the equipment will be thoroughly cleaned and decontaminated to equipment restoration industry standards of less than 20 µg/in2 of contamination.

This includes the removal of all smoke, soot, water and moisture contaminations that may have been caused by the loss incident. If it has not met industry standards then Newtron Group will re-clean the items at no cost to the insured.

### Defects in Workmanship

We will correct, at our own cost, any defect in workmanship that both Newtron Group and the insured agree that is our fault.

If it requires the use of the insured's employees and/or third party employee and resources to correct the defect because of feasibility or logistical reasons, Newtron Group will pay for the cost of the work, parts and labour directly related to correcting the defect, as long as it is agreed upon ahead of time and the amount is fair and reasonable for the work required.

## Re-occurrence of corrosion

Any re-occurrence of corrosion within the one year time frame will be treated the same way as Defects in Workmanship as stated above.

This is applied in cases where it can be determined and agreed upon by Newtron Group and the insured that the corrosion is related to the original loss, not a pre-existing condition, not the result of normal operation after the original loss, not due to abuse or misuse, and not the result of unintended incidents or accidents that happened after the original loss.

# In Closing

When an equipment restoration, cleaning and consulting authority is needed on a claim that involves equipment and electronics, call Newtron Group at **1-905-458-1400** or **1-800-238-3734** for 24 hours emergency service.

Newtron Group offers a complete range of services for industrial, commercial, and high-tech losses. Their team of fully trained experts can be on site within hours of the loss - conducting tests without delay and providing detailed reports on the cost of restoration and/or replacement.

Regardless of the size of the claim and where it is located in Canada, our experience has shown that it is often more cost-effective to restore than to replace most types of equipment.

Newtron Group utilizes state of the art, precision restoration techniques which meet or exceed military specifications for cleanliness, the industry's highest standards.

By applying sophisticated quality control inspections to ensure reliability, they guarantee all their work to the insured's satisfaction. Newtron Group will put the insured back in business quickly to help reduce the loss.

Newtron Group is the solution provider for industrial, commercial, governmental, institutional, medical, manufacturing and high-tech losses, nationwide.

# Reference Sources

Referenced and sourced from the Department of Energy, United States of America, DOE Handbook – Fire Protection – Volume II - Prepared by Hughes Associates, Inc.

Referenced and sourced from the Guidelines for Handling Water- damaged Electrical Equipment published by the National Electrical Manufacturers Association.

# Scan our QR Code and take our digital handbook with you everywhere!

This handbook is designed to support insurance professionals and inform businesses about equipment restoration after a disaster or loss.

It includes technical information about the impacts of fire, smoke and water damage as well as Newtron Group's processes to restore equipment to pre-loss condition.

Published by Newtron Group, 8 Indell Ln, Brampton, ON L6T 3Y3

# Equipment Restoration Handbook.

The primary objective of this guide is to provide a precise and comprehensive introduction and technical reference focused on equipment corrosion, assessment, and restoration.

Geared towards professionals in the property insurance and property restoration industry, this guide aims to serve as a valuable support tool for their endeavors.

Additionally, this tool serves the purpose of enlightening the insured individuals on the equipment restoration process and the anticipated outcomes they can look forward to.

Scan or visit www.newtrongroup.com today!

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