



Sea Salt Spray from Hurricanes *Debunking the Myths*

Do you have an Insured, property owner or their consultant claiming salt spray damages to interior building systems or contents after a hurricane? Is this a viable claim or even a common occurrence? Please read on to learn how rare salt spray damage actually is and how testing can debunk or verify these claims.

The rain associated with hurricanes is the same as any other precipitation event – *fresh water*. It is probably the freshwater of the hurricane rain that is most important factor in minimizing the inland distribution of salt aerosols and salt spray, via a washout mechanism. Of note is that Hurricane Inex in South Florida (1966) produced almost no measurable rain. Salt-spray was reportedly deposited several miles inland along the storm track (stated as cause of vegetation damage) as a result of the lack of rain during this Hurricane. Several additional events of salt spray transport inland have also been reported after low precipitation hurricanes.¹

Four potential mechanisms do exist for the potential enhancement of sea salt deposition onto structural and indoor surfaces inland from the beach during hurricanes, in comparison to the normal marine atmospheric environment:

1. Salt in hurricane related rainwater:

The amount of sea-salt measured in hurricane rainwater has been shown to be significantly less than,² to a maximum of just 50% more³ than normal precipitation. Since normal precipitation contains only trace levels of salts, the contaminants within hurricane related rainwater is expected to be the least concern with hurricane damage assessment.

2. Salt from aerosolization (jet & film droplets from breaking bubbles):

In several studies⁴, the maximum amount of salt aerosol, known as the mass threshold, was determined to be based on the number of breaking waves as a function of time. It was also

¹ Pirone, P.P. (1959). Tree Maintenance. 6th Ed. Oxford University Press, NY, NY. 514 pp.

² Padilla, H.G., R. Belmont, M.B. Torres, and A.P. Baez (2000). "Hurricanes Pauline and Nora Rainwater Chemical Composition." *Can. J. Earth Sci. Rev.*, Vol. 37, No. 4, pp 569-578.

³ Schaefer, D. and W. McDowell (2000). "Luquillo LTER: A 'Field of Dreams' for Rain Chemistry Research". *The Network News, LTER Newsletter*, Vol. 13, No.2, Fall 2000, 3 pp.

⁴ Krzyzanowski, M.E. and A.L. Myerson (1985). "An Aerosolization Study of a Model Compound of a Ptychodiscus brevis Toxin and Initial Experimentation with the Cultured Toxin." Toxic Dinoflagellates, Anderson, White and Baden Ed., Elsevier Publishing Co. Inc., pp 315-320.

determined that the wind speed thus does not impact the mass of sea-salt aerosol produced.⁵ This means that the production and subsequent deposition of salt aerosols would not be expected to be greater during a hurricane than during the normal long-term fluctuations of the coastal environment. In fact, due to the massive amounts of fresh water rain associated with hurricanes, the deposition of marine aerosols onto elevated surfaces away from the immediate beach zone should be minimal.

3. Salt from “Spume Droplets”⁶:

A spume droplet is the technical term and the physical mechanism for so-called “salt spray”. Spume droplets are actual liquid seawater removed by the wind from breaking wave crests. Again, as with the aerosolization mechanism, the number of breaking wave occurrences, not the wind speed, is the dominant factor in spume production and migration inland.⁷ Spume droplets are large and heavy, thus they have a maximum mass and distance threshold based on the size of these droplets. Most spume droplets or salt-water spray are washed out by rainwater, fall back into water or deposit onto the immediate beach zone before evaporation or deposition inland. Supporting this fact is that most damage to plants as a result of salt-water spray (non-storm surge) is reported to occur within 300m (1,000') of the ocean.⁸

4. Salt from re-entrainment of dried storm surge water:

As with all water contamination events, redistribution of dried salt left behind from a storm surge can occur during the clean up if water is allowed to evaporate and is not flushed off of affected surfaces soon after the surge recedes. Restoration and reconstruction workers can re-distribute the dried salt into the indoor air stream with potential deposition onto interior surface. This was not a significant problem with Hurricane Katrina (outside of the New Orleans Area) due to rapid recession of the storm surge.

Recent Data

We have made numerous measurements of chloride, sulfate and pH on mechanical, machinery, electrical and electronic equipment surfaces on indoor and outdoor systems in the process of damage assessment of facilities impacted by hurricanes beginning with Andrew in 1992 and continuing through the massive storms of Charlie / Ivan (shown above) in 2004 and 2005 (Katrina / Rita) seasons. Surface chloride concentrations were typically used as the primary indication of sea-salt contamination during these assessments.

Of interest is that normal to even less than normal chlorides concentrations have been measured at almost all of the approximately 50 facilities sampled (total number of >2000 samples). The low chloride concentrations are actually a mildly surprising finding for surfaces within buildings near the Gulf of Mexico, where higher concentrations of chlorides in common surface dust are

⁵ Shinozuka, Y., A.D. Clarke, S.G. Howell, V.N. Kapustin, and B.J. Barry (2004). Sea-salt Vertical Profiles over the Southern and Tropical Pacific Oceans: Microphysics, Optical Properties, Spatial Variability and Variations with Wind Speed. *J. Geophys. Res.*, Vol. 109, No. D24.

⁶ Anguelova, M., R.P. Barber and J. Wu (1999). “Spume Drops Produced by the Wind Tearing of Wave Crests.” *J. Phys. Oceanog.*, Vol. 29, No. 6, pp 1156-1165.

⁷ Pielke, R.A. Jr. and R.A. Pielke Sr. (2003). “Hurricane as an Extreme Meteorological Event.” Handbook of Weather, Climate and Water: Atmospheric Chemistry, Hydrology and Societal Impacts. T. D. Potter and B. R. Coleman Eds., John Wiley & Sons, Inc., pp 789-805.

⁸ Sinclair, W.A., H.H. Lyon, and W.T. Johnson (1987). *Diseases of Trees and Shrubs.* Cornell University Press, Ithaca, NY 575 pp.

expected on a normal basis. The only exceptions to this finding were for surfaces directly exposed to a storm surge (i.e., were submerged) and for un-submerged, partial areas of facilities that were actual beachfront properties.

Enhanced airborne salt deposition on interior facility surfaces, either from an aerosol or salt spray source, was measured for mechanical systems at two hotels directly on Pensacola Beach, FL (resulting from Hurricane Ivan) and at one (of three) barge casino on the beach in Biloxi, MS, (Hurricane Katrina). In all three cases, salt deposition was attributed to the complete loss of an external wall during the hurricane, and also was clearly evident both via chloride test measurements and visually. Chemically, the chloride concentrations on affected surfaces were measured at $>440 \mu\text{g} / \text{in.}^2$ ($440 \mu\text{g} / \text{in.}^2$ being the upper limit of our semi-quantitative test method). Visually, the hygroscopic (“moisture absorbing”) chloride salts were obvious due to the wet, slightly oily nature of the mechanical equipment surfaces (both bare metal and painted surface). Oxidation (rusting) of the bare metal surfaces in these cases was also pronounced.

Since ocean water is comprised of anywhere from 28 to 32 parts per thousand (as opposed to per million for most other contaminants) of chloride (“chlorinity”), any salt spray or salt aerosol from a hurricane event impacting machinery or other equipment surfaces would reveal extremely high chloride surface concentrations. Past studies of electronic equipment facilities located within a few miles of an ocean show that normal surface concentrations of chlorides are expected to be 2-3 times that of the $1\text{-}2 \mu\text{g} / \text{in.}^2 / \text{yr.}$ of chloride for similar in-land office buildings⁹. High occupancy buildings (such as hotels) are nominally higher in expected surface chloride concentration, while a manufacturing environment also adds a multiplier of at least 1.5 times the chloride contamination rate.¹⁰

To put these values into further perspective, water residue from direct salt water deposition or salt-spray that would result in a significant short-term reliability concern for mechanical or electronic equipment, would result in chloride values of significantly $>400 \mu\text{g} / \text{in.}^2$. Comparison may also be made to values utilized by various industries in determining acceptability of new products, as well as contamination levels known to be restorable or known to be damaging. The military specification for highly reliable new electronics is $<20 \mu\text{g} / \text{in.}^2$ of chloride concentration.¹¹ The telecommunications industry uses a guideline of $<50 \mu\text{g} / \text{in.}^2$ for chlorides as a guideline for long-term reliability concern for high density circuitry. Chloride values of $>200 \mu\text{g} / \text{in.}^2$ are stated to be of significant concern to the restorability of electronic equipment and above $600 \mu\text{g} / \text{in.}^2$ are thought to be questionable for restoration.¹²

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⁹ Sinclair, J.D.; Psota-Kelty, L.A. and C.J. Weschler. (1985) “Indoor/Outdoor Concentrations and Indoor Surface Accumulations of Ionic Substances.” Journal of Atmospheric Environment, Vol. 19, No. 2, pp 315-323, 1985.

¹⁰ Krzyzanowski, M.E. (1990) "Applications of Ion Chromatography in the Disaster Recovery of Electronic Equipment," 41st Annual Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, N.Y., NY 3/90.

¹¹ Military Specification 28809A, October, 1981.

¹² Reagor, B.T. (1992). “Smoke Corrosivity: Generation, Impact, Detection, and Protection.” J. Fire Sci., Vol. 10, April/May 1992.