White Paper

The Victaulic Vortex™ Fire Suppression System

Fire Suppression for Electrical and Electronic Applications

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Introduction

From a smoldering circuit board to a switch gear explosion, the risk of electrical fire in data, power generation and telecommunication centers is an ever-increasing concern for the owners and operators of these facilities.

Today's data center and electronics industries are looking for a fire suppression solution that is safe, effective and mindful of the environment *(See SNAP Listing[1])*. The Victaulic Vortex™ Fire Suppression system is a unique, hybrid technology, utilizing both water and nitrogen in a combined suspension to both cool the hazard area and remove the oxygen that sustains the fire with a high velocity, low pressure delivery. This swirling, vortex-like distribution fills the hazard space and quickly extinguishes the fire with little or no water residue. Electronics are kept dry and there are absolutely no toxic agents or chemicals involved.

Problem Statement

Equipment Enclosure Challenges and Water Mist Solutions

Equipment enclosures, commonly found in data center and electronics facilities, present significant fire suppression challenges and are considered "local application" hazards. Traditional single-agent water mist systems often need to be installed directly within an enclosure to suppress a fire. An internal installation would require the equipment to be de-energized before a water mist system discharge occurs in order to prevent damage and injury. Further, a shunt trip can be triggered when the current draw is excessive for the equipment.

If fire suppression is required in a larger area, where multiple enclosures or pieces of equipment may need to be protected, this is considered a "total flooding" application. In a total flooding scenario, the water mist concentration that enters an enclosure will not be great enough to cool and suppress the fire unless the top is open.

In either scenario the equipment inside the enclosure would be subject to extreme wetting conditions along with possible damage.

Gaseous Suppression Systems and Oxygen Reduction

In most cases, gaseous systems require hold time concentrations and must pass a "fan test" to be accepted as a viable option. Some systems require the space to

be modified to provide room integrity seals so the gaseous agents remain in the hazard area during a fire event.

Where water mist systems are designed to reduce the temperature in the fire space, inert gas systems work to reduce the amount of oxygen available to sustain the fire. These systems do not allow for cooling in the space, leaving open the possibility of re-ignition if room integrity is not maintained for a defined period of time.

Maintaining Room Integrity

Effective maintenance of the concentration of suppressing agent is a value of room integrity. Proper room integrity for many inert gas systems requires significant custom construction to control air flow. Sealing a room to meet specified leak rates can be a large and costly challenge for facility owner and contractors.

Protecting the Environment

Inert gas suppression systems also present several challenges in today's sustainability-focused marketplace. These systems utilize chemical agents and halocarbons to achieve fire suppression which often raises environmental concerns. Therefore, efforts have been made to find alternative solutions that are friendly to the environment and occupants *(no HF or ozone depletion).*

System Downtime and Reset

Beyond room integrity and environmental concerns, the full life-cycle of a system must be considered, including the cost and complexity of system reset after a discharge. In many cases, agent storage cylinders need to be returned to the manufacturer for refill with proprietary agents or removed from the system for weighing, costly in both time and money. Facility owners and operators who are focused on minimizing facility downtime are in need of more time and cost-effective solutions.

The Victaulic Solution

The Victaulic Vortex™ Fire Suppression System uniquely uses hybrid technology to deliver a blend of water and nitrogen to suppress and extinguish both local application and total flooding fires. The Victaulic Vortex system has been proven effective for small, smoldering enclosed fires and large, heat-releasing fires in open spaces.

By combining nitrogen and water, the Victaulic Vortex System creates a homogeneous suspension of nitrogen and sub 10 micron water droplets that can penetrate through vented type enclosures to extinguish a fire. When the mixture enters the enclosure, both the nitrogen and water attack the fire simultaneously, the water cooling the space and the nitrogen reducing the oxygen content and generating steam. This results in complete fire suppression without significant wetting or the chance for re-ignition.

The Victaulic Vortex System is completely friendly to the environment, utilizing no toxic agents and has been identified by the Environmental Protection Agency as having a Global Warming Potential of zero.

Since the system discharges with high velocity under low pressure, the hybrid suspension swirls through the space, overpowering the fire plume and not requiring room integrity to remain effective. Since the system does not require room integrity to remain effective, this additional construction or retrofit cost can be avoided.

Also, since the Victaulic Vortex system only requires water and pure nitrogen, storage bottles can be quickly and cost-effectively refilled on site or cylinders can be replaced by a local gas supplier. This minimizes system and facility downtime, increasing productivity and profit. The system can be designed to receive water piped in or stored in a portable tank. De-ionized water is recommended for systems where electrical equipment is in the hazard space to minimize potential conductivity.

Victaulic Vortex System Testing and Benefits

Benefit 1 - Effective Fire Extinguishment

Factory Mutual, Underwriter's Laboratories and many clients have witnessed a broad range fire tests demonstrating the effectiveness of the Victaulic Vortex system. *(See Vortex FM approval[2], UL 2127 equivalency report[3] and applicable fire test results).*

As an example, the Victaulic Vortex system was tested in accordance with requirements listed in ANSI/FM 5560 Appendix G, demonstrating the successful extinguishment of a cable bundle fire with the Vortex System *(See Figure 1).*

Figure 1 - Cable Bundle-Post Fire

Benefit 2 - Safety of Sensitive Electronics

Unlike other technologies, the Victaulic Vortex System can be installed in a total flooding configuration and remain completely effective at fire extinguishment inside an enclosure.

With system emitters installed outside the enclosure, live circuits do not have direct exposure to the water and nitrogen suspension discharged by the system. This greatly minimizes the moisture level in the enclosure.

Due to the high velocity, vortex distribution effect of the system, the mixture of nitrogen and water travels into the enclosure through ventilation openings. This ensures that circuit boards and components are not damaged due to high levels of moisture or excessive wetting.

Fire Test 2.1 - Energized Computer Equipment

The described fire scenario was performed at the Victaulic Edison Hydraulics Laboratory in Stewartsville, NJ.

A vented enclosure containing microprocessor-based electronics was placed inside a 4624 ft^3 (130 m^3) room along with laptop and desktop computers. A cup of heptane and a wax-based candle were ignited inside the enclosure *(Figure 2 and 3)* and allowed to burn for 15 seconds. A dish of Anhydrous Calcium Sulfate (Drierite) was placed in the desktop computer tower and another inside the vented enclosure to compare the moisture levels inside and outside the enclosures. A relative humidity sensor and thermal couple were placed inside the vented enclosure to monitor the conditions before, during and after the fire.

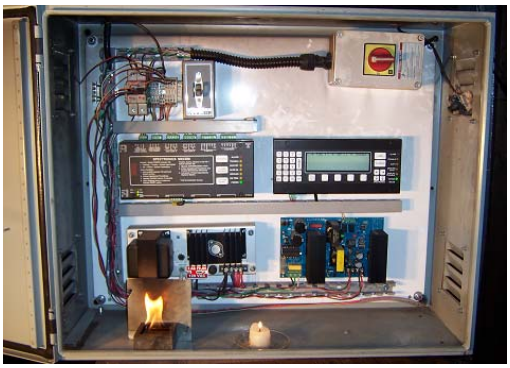
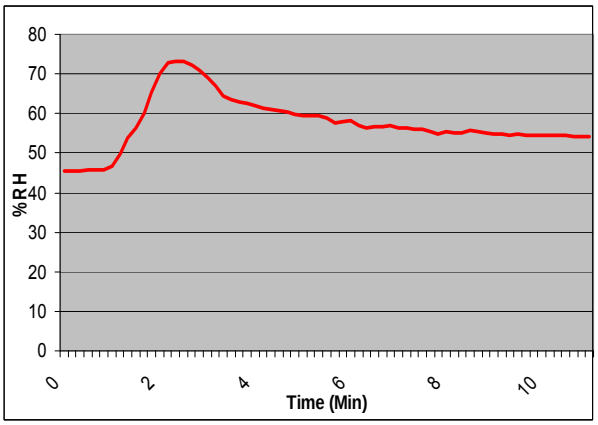


Figure 2 - PLC Configuration

Figure 3 - Laptop and Desktop PC

The Victaulic Vortex System was discharged for 1 minute, 36 seconds *(See data report)*, at which point the two fires inside the enclosure were extinguished *(note: the Victaulic Vortex System can be configured to increase or decrease extinguishment time by changing the emitter size or count)*. The equipment remained energized throughout the fire tests and remained powered for 60 days after completion of the test.

After discharge, the internal circuit boards were completely dry and the equipment was operating as designed. The relative humidity reached a peak valve of 73.29 % *(See graph 1)* with a net increase of 30% RH. The Anhydrous Calcium Sulfate remained its natural blue color *(See figure 4)* showing no increase in moisture.



Graph 1 – Relative Humidity

Figure 4 - Anhydrous Calcium Sulfate

After 60 days of operation, circuit boards and various components were examined and photographed *(See figure 5)*. The samples show no signs of corrosion or damage.

Generally, electrical components will show pitting and green discoloration a few days after exposure to water.

Figure 5 - No Corrosion Between Pins

Test 2.2 (No Fire) - ANSI/FM 5560 Appendix G.

A computer enclosure similar to that used with an IBM AS 400 system was placed on a vented sub-floor. Two dishes of Anhydrous Calcium Sulfate were placed in the enclosure, along with two mirrors to indicate moisture levels inside the cabinet *(See figure 6).* Two additional samples of Anhydrous Calcium Sulfate were placed outside the enclosure for comparison.

Figure 6 – Computer Enclosure

Figure 7 – Anhydrous Calcium Sulfate samples

The Victaulic Vortex System was discharged and all four dishes of Anhydrous Calcium Sulfate and mirrors showed little to no moisture levels *(all blue). (See Figure 7).*

Benefit 3 - Safe For Use On High Voltage Equipment

During the following tests, the Victaulic Vortex System was installed in both local and total flooding configurations. Three types of high voltage tests were successfully performed up to 10KV *(limited by equipment).*

Test 3.1 - Local Application, Charged Plate

A Victaulic Vortex emitter that was electrically isolated from the rest of the system was discharged onto a copper plate with a 10KV potential *(See figure 8).* A milliamp meter was placed between the emitter and the ground to measure any current flow. The distance between the plate and emitter was varied from 10 to 2 inches. At a distance of 1.5 inches the air broke down and an arc was created.

Figure 8 – Emitter discharge set up with copper plate

An arc was not witnessed or measured during or after a discharge. At no time did the potential 23mA flow through the emitter and ground. The maximum current was 168.58µA.

NIOSH defines the maximum “let go” current to be 16mA and 1mA is “barely noticeable”. All currents measured in these tests were far below these levels.

The above tests are similar to ANSI/UL711 for rating class C fire extinguishers. Reference Table 1 for test results:

		TEST 1 µA	TEST 2 µA	TEST 3 µA	TEST 4 µA
Base Line Current		13.71	20.87	31.69	44.22
Discharge Current		170.6	173.5	184.41	212.8
Total Current		156.89	152.63	152.72	168.58

Table 1 – Current values during high voltage discharge tests

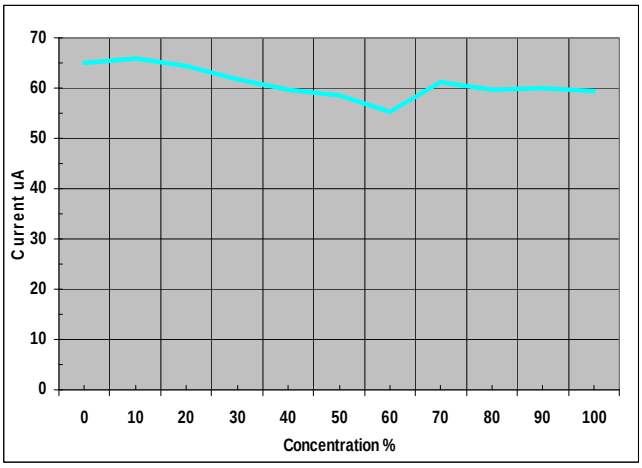
Test 3.2 - Total Flooding, Enclosed Bus Bar

Two copper bus bars were charged to 10KV and placed into a vented enclosure 1.5 inches apart form each other *(See figure 9).* Two power supplies, PLC and an LCD display were also energized during the testing.

Inside the enclosure, a candle and a heptane fire were lit in the enclosure and allowed to burn for 15 seconds. The Victaulic Vortex™ System was discharged for approximately five minutes while current flow was measured from one bus bar to the ground.

Figure 9 – Vented enclosure with copper bus bars

An arc condition was never created during the duration of the test nor did the current flow exceed 68.87µA *(See graph 2).* All readings were well below the NIOSH standard of 16mA. All equipment remained powered and undamaged during and after the discharge.



Graph 2 – Current measurement during enclosed bus bar test

Test 3.3 - Total Flooding, Unshielded Bus Bar

Similar to Test 2, two copper bus bars were placed seven feet directly below a Victaulic Vortex emitter. The system was then discharged for a total of five minutes *(100% concentration)* on the 10KV bars. During the discharge, current was read and recorded *(See table 2).*

% Concentration	Current uA
0	51.56
10	52.94
20	73.28
30	97.1
40	515
50	471
60	437
70	444
80	446
90	449
100	450

Table 2 – current values during second test with copper bus bars

The results above show a maximum current flow of 515µA (.515mA). This value is far below the 1mA of "barely noticeable" current, proving this type of application would be effective on charged equipment. At no time did an arc condition occur.

Implementation

When the Victaulic Vortex™ system is installed in data centers, computer rooms or any other sensitive electrical application; system emitters should be placed so that they have no direct impingement on the device. The preferred installation practice would be to have emitters mounted in a sidewall configuration and arranged so that the blended suspension of water and nitrogen would be directed down hot and cold aisles. The water source should be a captive supply of de-ionized water with a blanket of nitrogen to ensure the purity of the water over time.

These applications shall use a water flow cartridge of .26 gpm along with 5/8 inch emitter or equivalent gas/water ratio. A pendent orientation can be used but a sidewall installation is preferred.

For sub-floor applications, or tight spaces, a specialized fan-type foil shall be used so excessive wetting will not occur on the floor and ceiling.

The same system design practices shall also apply to high voltage installations. The Victaulic Vortex emitter shall be placed so that the water and nitrogen suspension does not have any direct impact upon the charged device. Whenever possible, a means of equipment shut down before a discharge would be preferred but is not mandatory.

Summary

The hybrid technology of the Victaulic Vortex™ System provides an innovative, safe and effective fire protection solution for installations that contain electronic equipment. The vortex effect created by the patented system emitter design allows the mixture of sub micron water droplets and nitrogen to effectively enter vented enclosures and suppress fires within the enclosure.

Water mist systems that use single fluid technology cannot provide the same level of protection as the Victaulic Vortex system. Since a single fluid system will need a nozzle placed inside of the enclosure to extinguish a fire, it is certain that the powered equipment would be damaged due to extreme wetting conditions.

Facility owners and operators will benefit from the Victaulic Vortex system's minimal wetting operation, simple maintenance, environmentally-friendly design and rapid return to normal operations after system discharges.

End Notes

1) **U.S Environmental Protection Agency**
http://www.epa.gov/Ozone/snap/fire/lists/flood.html

2) **FM Global**
http://www.approvalguide.com/CC_host/pages/custom/templates/fm/index.cfm?product=111216

3) Contact Victaulic For Underwriter's Laboratory (UL) Report
http://ulstandardsinfonet.ul.com/scopes/scopes.asp?fn=2127.html

Work Cited

1) William Reilly, Victaulic
Victaulic Vortex vs. Clean Agent and Water Based Systems
(WP-04, April, 2008)

2) Andrew Hills, Terence Simpson and David Smith, Fire Safety Internal
Water Mist Systems For Telecommunication Switch Gear And Other Electronic Facilities