INERGEN Acoustics Testing Position Paper

The Issue

In recent years, there has been considerable confusion in the marketplace about why some data center hard disk drives (HDDs) are damaged in the wake of clean-agent fire suppression system discharge.

When the issue first came to light, the fire suppression community was mystified as it searched for a cause. Was it the sudden increase in room pressure during clean-agent discharge? The discharge gas itself? Or, was some other part of the fire suppression process to blame? And, perhaps most puzzling, what caused the phenomenon to surface at that time? Clean-agent fire suppression systems had been discharged successfully in data centers for years without incident. What changed?

When we began to investigate a possible cause, the finger of suspicion quickly pointed to noise, as some of the initial incidents reportedly took place when fire suppression warning alarms sounded without agent discharge. Early industry testing also indicated noise was to blame and some in the fire protection community began to take action based on those preliminary results. At Tyco, we wanted to be certain. As a leader in clean-agent fire suppression, our duty was to fully understand the data degradation phenomenon. We sought guidance from IBM in monitoring the state and performance of HDDs during discharges and collaborated with Nelson Acoustics, an industry-leading acoustics consultant, to conduct what we believe is the most exhaustive study of the issue to date.

Tyco's Position

Under a test protocol developed jointly by Tyco, IBM and Nelson Acoustics, we conducted a series of trials in which a clean-agent fire suppression system was discharged in an environment containing HDDs typically found in data centers. The results confirm a single cause of data degradation: disk drive sensitivity to noise.

As HDDs have evolved to store more and more data on each square inch of disk space, the tolerance for the data head to be off track has shrunk accordingly. It's likely that the reduced tolerance resulted in greater sensitivity to noise. As a result of the changing technology, we are taking the following steps to better protect our customers' hardware:

- We are redesigning our INERGEN system nozzle to reduce its acoustic footprint.
- We will pursue agency approval of the redesigned components and will provide listed, backward-compatible replacement nozzles.
- We recommend the data center industry take additional noise-control measures to reduce risk.

It's important to note that our tests involved the discharge of inert gas only; halocarbon testing may be conducted at a future date.

This position paper details the findings of our study and the planned strategy to minimize disruptive noise generated in the data center environment.

Our Study Components

The tests were conducted over a series of days and included:

- **Fifteen discharges of INERGEN agent** into an enclosure containing 35 operating HDDs from four major manufacturers typically found in commercial data centers.
- **Multiple piping and component configurations** based on real-life data gathered from actual discharge incidents. (See Figures 1, 2 and 3.)
- **The testing of various audible alarm devices** (horn, bell, strobe and siren) to determine their impact independent of an agent discharge.
- **Extensive measurement and recording instrumentation** that documented the physical effects and performance of the HDDs in terms of impact on Input/Output (I/O) performance.
    - o A .wav file (sound recording) was taken of actual inert gas discharges. This sound recording was used to benchmark hard drive performance.
    - o The hard drive performance was monitored each time the .wav file was cycled and each time the dB level was increased.

INERGEN Component Locations (Set-Up A)

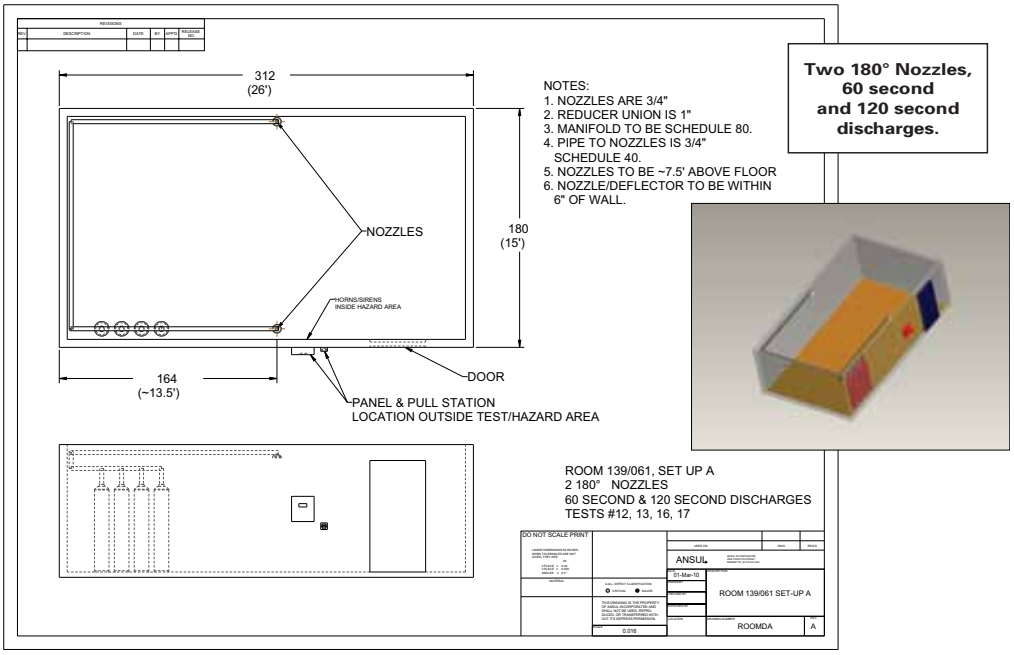

Figure 1

INERGEN Component Locations (Set-Up B)

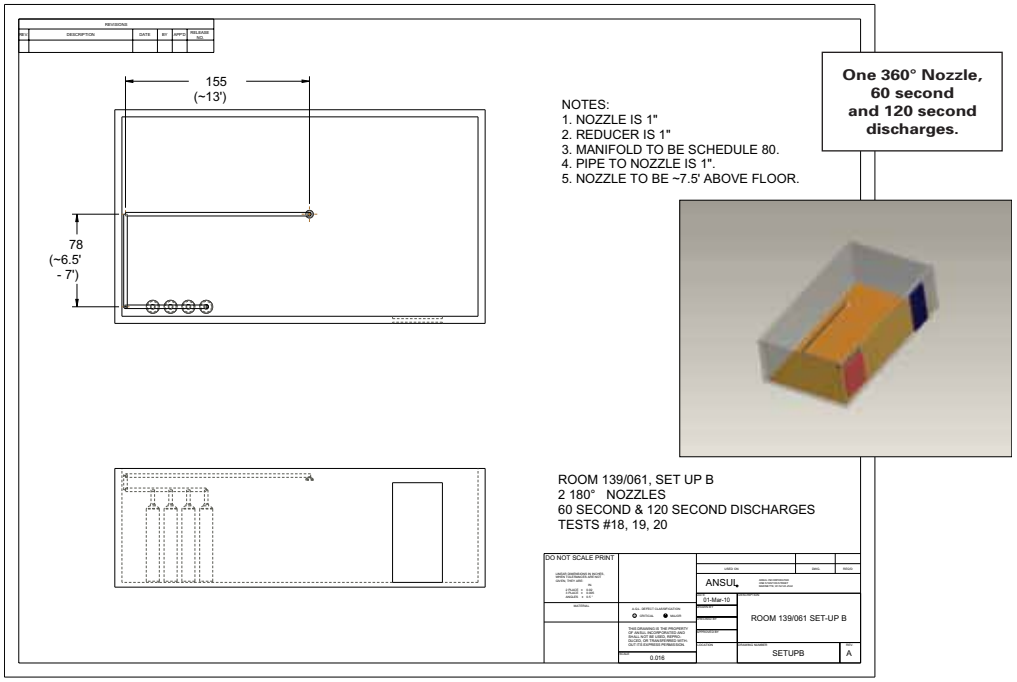

Figure 2

INERGEN Component Locations (Set-Up C)

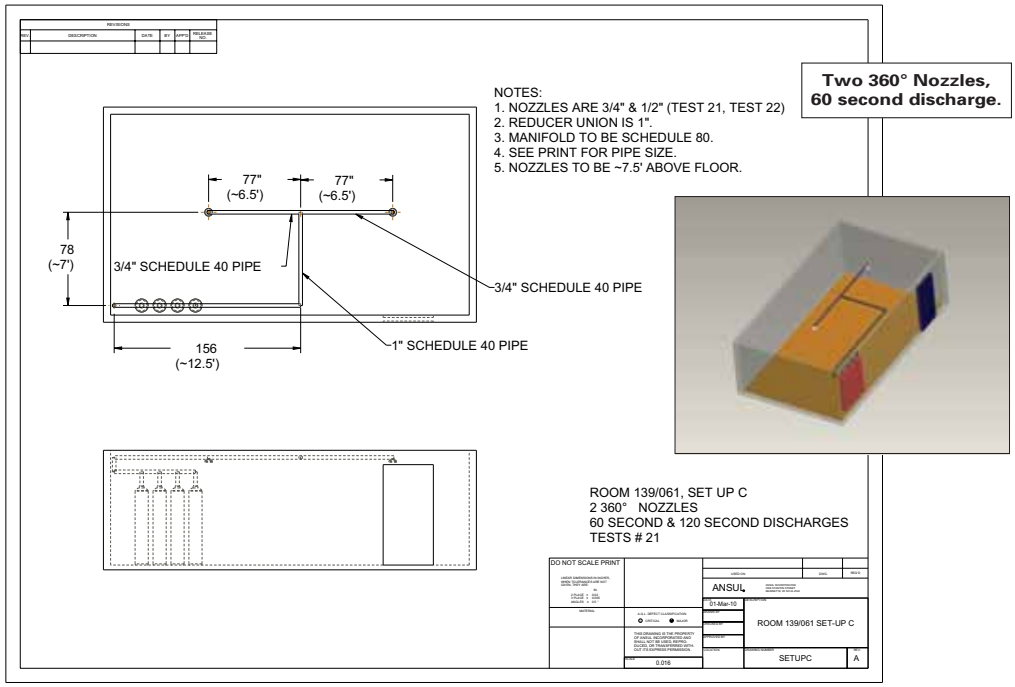

Figure 3

Our Study Results

Two primary conclusions were drawn from the joint study.

1. The mere introduction of INERGEN agent itself into the enclosure housing the HDDs did not result in degradation of HDD performance.

2. High-decibel sound levels with high frequency content were found to disrupt HDD performance as shown below in Figure 4.

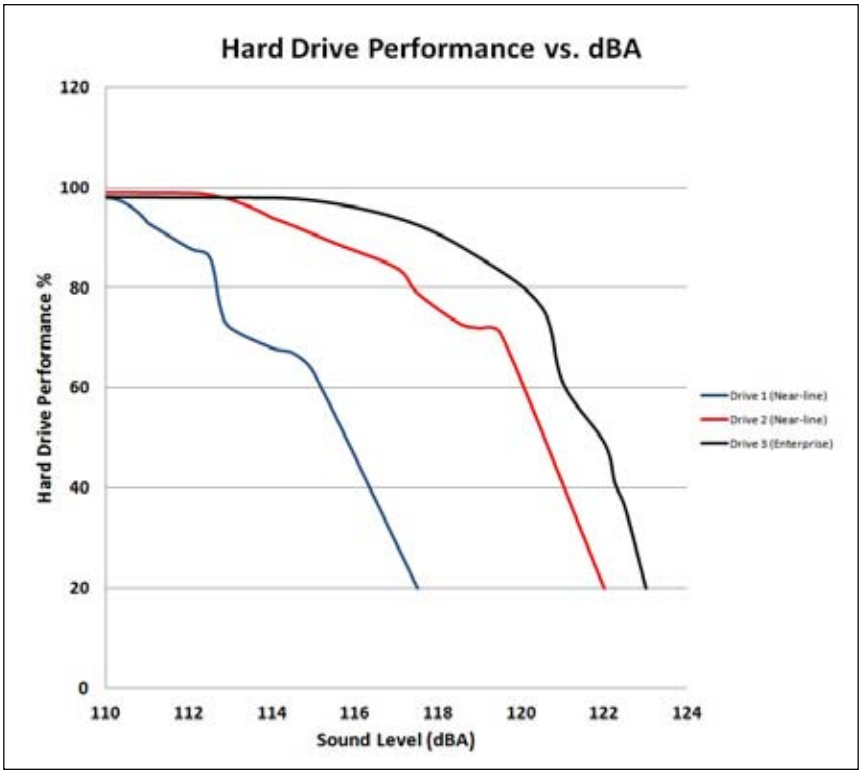

Figure 4

Our study shows disruptive sound levels can be produced either by a system discharge or, to a lesser degree, by certain audible devices used to sound an alarm prior to discharge. Our testing criteria assumed a hard drive could drop to no lower than 20% of its I/O performance (80% degradation) and still be expected to return to its normal operating condition.

System Discharge Noise

In a clean-agent fire suppression discharge, the pressure used to expel gas makes a significant amount of noise. In our study, we tested both currently existing system nozzles (See Figure 5) and a prototype nozzle designed to minimize noise (See Figure 6).

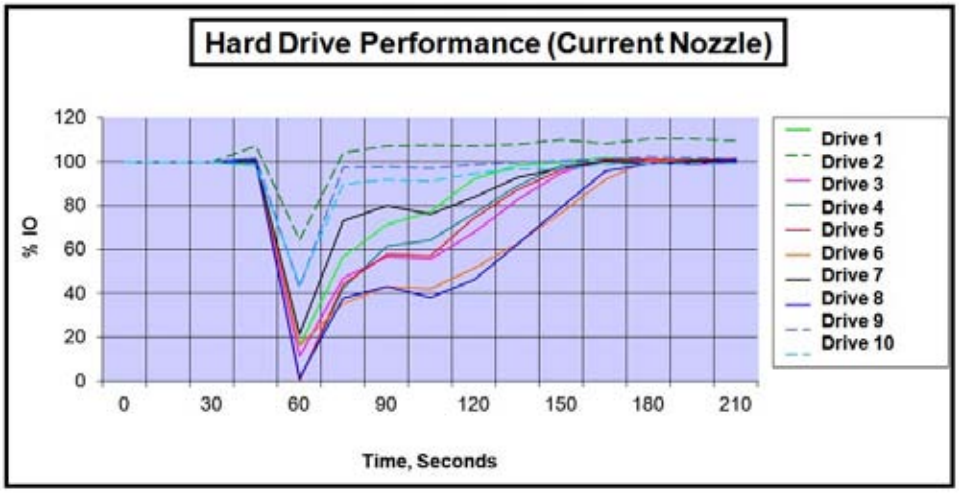

Figure 5

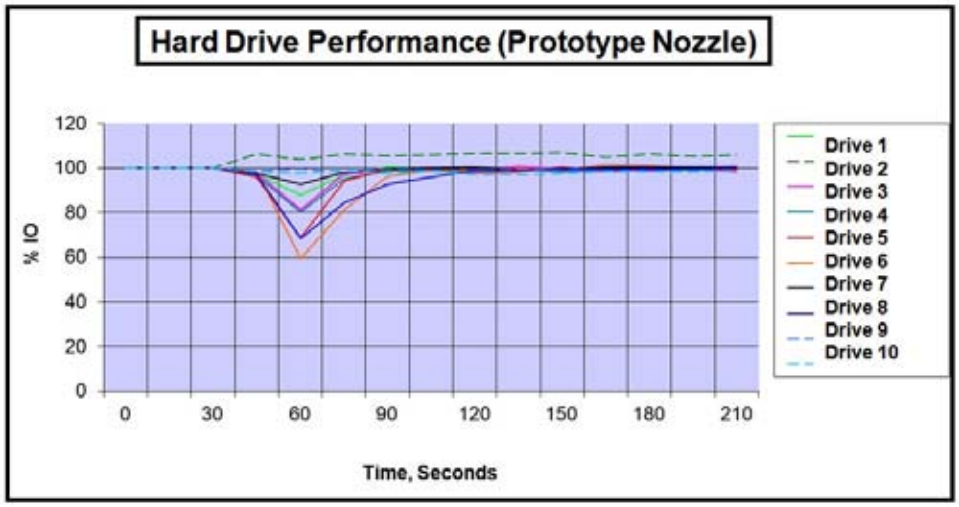

Figure 6

System Alarm Noise

Clean-agent system alarms typically include one or more horns, bells, strobes and sirens. According to standards and codes, these alarm devices must generate sound levels between 90 and 120 dB.

In our investigation, we tested the sound generated by each of the four common alarm devices on hard disk drive performance.

- The horn, bell and strobe - with levels between 90-100 dB - all had no negative effect on HDD performance. (See Figure 7.)
- The pneumatic pressure siren was shown to have a measurable impact on I/O per second. In one server, performance was reduced by 20% to 50%. Sirens average 115-125 dB. (See Figure 8.)

The study also concluded that certain sizes and classifications of HDDs exhibit more or less sensitivity to these levels.

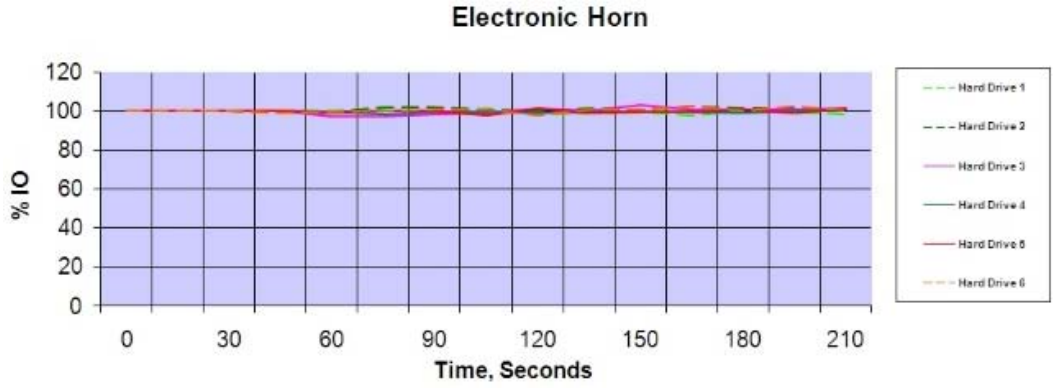

Figure 7

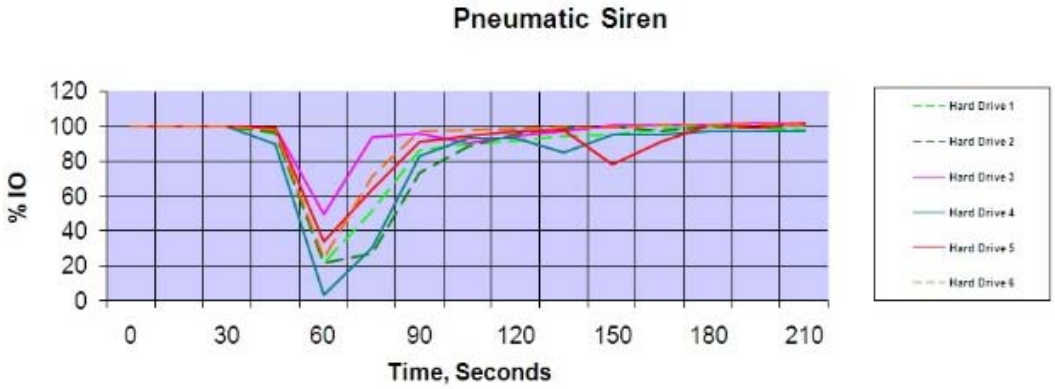

Figure 8

Our Strategy Moving Forward

As a result of our comprehensive testing, we have developed a strategy to minimize disruptive noise generated in the data center environment. We will:

- Redesign our fire suppression system nozzle to reduce its acoustic footprint based on the results of our 2010 tests.
- Pursue agency approval of the redesigned components and provide listed, backward-compatible replacement nozzles.
- Recommend that data centers take additional noise-control measures to minimize risk.

Redesign System Components

We are redesigning our system components to have the lowest acoustic footprint possible without impacting agent distribution based on our 2010 testing of HDDs typically found in commercial data centers.

Pursue Agency Approval

We recognize the critical need to offer system components that meet agency approval, and we will pursue those certifications with the component redesign. We also recognize that achieving certification takes time. In the interim, we will consider bringing a redesigned solution to market to satisfy the emergency needs of our customers.

Recommend Additional Noise-Control Measures

While our redesigned nozzle will be critical to minimizing disruptive noise in the data center environment, we believe - and our tests have shown - that additional measures can be taken immediately to further mitigate risk.

De-energizing equipment prior to clean-agent discharge remains the recommendation of various codes and standards, such as NFPA 75 Protection of Information Technology Equipment 8.4.2.1. which states, "The power to all electronic equipment shall be disconnected upon actuation of a gaseous agent total flooding system..." Where possible, we recommend removing power from HDDs prior to any discharge event. This will allow the drive to "park" and greatly reduce the likelihood of data loss or damage.

If removing power is not possible, we recommend installers and end users take the following steps to mitigate the impact of sound levels on HDD performance:

- Consult with the computer equipment provider about noise sensitivity.
- Increase the number and decrease the spacing of suppression system nozzles used in order to decrease sound levels.
- Avoid very short discharge times. While extended discharge times were not shown to have any substantive effect on sound levels, it is possible that very short discharge times - less than 60 seconds - could result in higher sound levels.
- Avoid the use of pneumatic sirens which were shown to have a measurable impact on HDD performance. (See Figure 8, page 6)

Recommend Additional Noise-Control Measures (Continued)

- Check with your IT equipment manufacturer to see if rack doors with foam lined acoustic baffles are available for your equipment. The baffles reduce noise reaching the HDDs and were shown in our tests to significantly improve performance during high sound level testing. (See Figure 9.)

Test	Discharge Time	Nozzle	dB	Server A	Server B	Server C	Server D
No Doors	120s	Prototype	136	3 drives off line	1 drive destroyed	1 drive off line	3 drives off line
With Doors	120s	Prototype	136	1 drive off line	No errors	No errors	No errors

Figure 9

Our Commitment

We recognize that in data center environments, downtime and loss of data can be crippling. We are committed to ensuring that the very fire suppression equipment designed to protect data from fire does not contribute to its degradation. We will minimize the acoustic impact of our fire suppression system on data center hard drives based on the decibel and frequency thresholds identified in our 2010 study. We will achieve this goal by redesigning system components and by recommending that our customers take additional steps, as outlined in this document, to mitigate risk. Moving forward, we will continually monitor the impact of our system discharge sound levels in the data center environment.

References

For additional information on this topic, view/download the following documents:

Fire Suppressant Impact on Hard Disks

The Availability Digest, February, 2011

www.availabilitydigest.com/public_articles/0602/inergen_noise.pdf

Potential Problems with Computer Hard Disks when Fire Extinguishing Systems Are Released

Siemens Switzerland Ltd. Building Technologies, 2010

www.buildingtechnologies.siemens.com

Hard Drive Performance Degradation Due to High Level Noise in Data Centers

International Business Machines, September 2011

http://commerce.aip.org

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