Extinguishing

Potential damage to hard disk drives during discharges of dry extinguishing systems.

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When the fire protection industry became aware of potential damage occurring to hard disk drives during discharges of automated dry extinguishing systems, Siemens decided to find an answer to the problem.

After an intensive research phase, Siemens determined that the high noise level generated by conventional extinguishing systems during the discharge process was causing the damage. This conclusion led to the development of a new extinguishing system, named Sinorix™ Silent Extinguishing Technology.

With Sinorix Silent Extinguishing Technology, the extinguishing system operates at the same performance level as a conventional system, but with a significantly lower noise level. This is primarily due to the innovative new Sinorix Silent Nozzle, created to ensure disturbance-free operation of hard disk drives during the extinguishing process.

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Potential damage to hard disk drives during discharges of dry extinguishing systems

Data centers and server rooms are at the heart of the modern business world. With an estimated 35 million servers worldwide processing ever-increasing quantities of data throughout a global network of several billion devices, the need to ensure business continuity and protect knowledge from loss is essential.

When it comes to a fire in a data center, seconds count. In a data center or server room, the hardware, electrical power and extensive cabling that drive computing systems create a constant risk of potential ignition. In addition, many thousands of plastic components supply plentiful sources of combustible material. All these factors lead to an increased risk of fire.

In 2009, the fire protection industry became aware of potential damage occurring to hard disk drives (HDDs) during discharges of automated dry extinguishing systems. The damage ranged from automatic shutdowns to more severe disturbances, with corresponding losses of data. As a longtime pioneer in the development of advanced extinguishing products and backed by 160 years of experience in fire safety, Siemens decided to find an answer to the problem.

Tests were performed in three steps to verify the underlying reason why the HDDs were disturbed during the discharges. First, the HDDs were exposed to overpressure, at levels typically generated during discharges of dry extinguishing systems. During the second test, the HDDs were exposed to high noise levels. In the final test, actual extinguishing discharges were made.

The first test demonstrated that no damage to HDDs is caused by overpressure created by extinguishing discharges or by the equivalent pressure gradient in such a setup.

The second and third tests demonstrated that high noise levels created by extinguishing discharges may have negative effects on HDDs, which in the worst case may cause damage to HDDs.

Based on the results, Siemens developed Sinorix Silent Extinguishing Technology, with the innovative Sinorix Silent Nozzle at its core.

With Sinorix Silent Nozzle, the extinguishing process is designed in such a way that the noise level remains below the level found in tests to pose a risk to hard disk drives.

Thanks to its innovative linear design, the nozzle allows an efficient distribution of the agent into the protected area, at the same performance level as a conventional system. In addition, the discharge of the agent, and hence the sound, is focused in a predefined direction, preventing additional sound-generated problems.

In data centers, inert gas extinguishing systems are strongly recommended because of the high sensitivity of the server room equipment. Sinorix Silent Nozzle is therefore designed to use Sinorix CDT, with nitrogen or argon as the extinguishing agent.

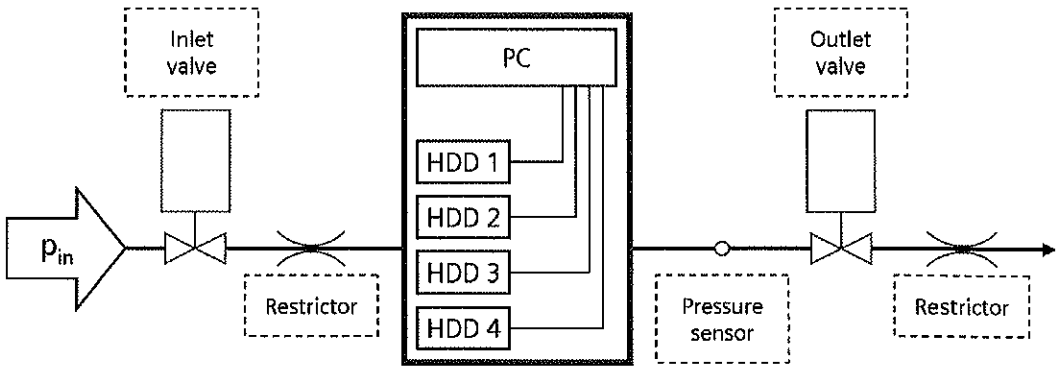
The Sinorix CDT technology consists of a cylinder valve with a pressure-regulating function which discharges the gas into the flooding zone at constant mass flow throughout the entire flooding time. This eliminates the peak at the beginning of the discharge and thus lowers the maximum noise level.

This paper is divided into three sections. The three tests are presented in the first section, based on the following questions:

1. Is the damage caused by overpressure?
2. Is the damage caused by high noise levels?
3. Are the laboratory results transferable to actual extinguishing tests?

The Sinorix Silent Extinguishing Technology, including Sinorix Silent Nozzle, is presented next, followed by a Question & Answer section with Siemens' recommendations for successfully protection of hard disk drives from damage.

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Is the damage caused by overpressure?

The delivery of a large amount of extinguishing agent into a protected area within a short period of time generates overpressure in the room. The first question Siemens addressed was whether overpressure was causing the reported damage to the HDDs.

For data centers, inert gas extinguishing systems are strongly recommended because of the high sensitivity of the server room equipment. Inert gases operate by reducing the oxygen volume concentration in the protected area to a level where the fire can not burn.

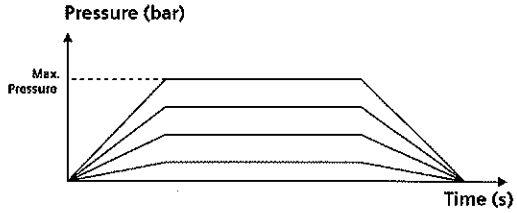
Depending on the fire risk, the oxygen volume concentration is generally reduced to in between 10% and approximately 14% in order to extinguish the fire. The amount of inert gas needed to protect a room is typically about half the volume of the room.

Overpressure flaps are used to limit overpressure by allowing the corresponding air volume to be displaced outside the room. Depending on the pressure resistance of the room, the design criterion for the overpressure flaps is typically from 1 to 3 mbar for normal building construction.

Test setup: Siemens performed a series of tests with typical HDDs[1] from several manufacturers. The figure above shows the test setup with 1 TB SATA HDDs from four manufacturers commonly used in data centers in 2009. To monitor the effects during the test, Siemens set the HDDs in constant operation and recorded typical performance parameters, such as S.M.A.R.T. information[2], data transfer performance, and linear and random seek performance.

During the tests, the pressure was increased via a nozzle opened by a solenoid valve. The pressure was then monitored by two pressure sensors, one for absolute pressure and one for sensitive differential pressure.

Pressure inside container



Siemens performed a series of tests with stepwise increases in the maximum overpressure and the gradient, up to a maximum overpressure of 170 mbar and a maximum gradient of 30 mbar/s.

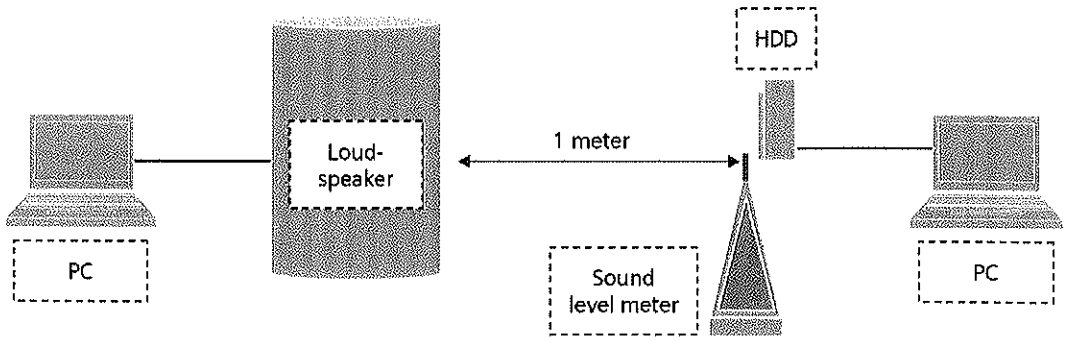
Conclusion: No negative effect on performance or damage to the hard disk drives was found. As a further test, the flow-limiting nozzle was removed. Even at 220 mbar for 3 seconds with a gradient up to 100 mbar/s, no negative effects on performance or damage were found.

The test proved that no damage is caused to HDDs by overpressure created by a state-of-the-art dry extinguishing system with overpressure flaps, or by the pressure gradient in such a setup.

[1] 3.5" drives in the enterprise storage category, 1TB capacity, 24/7 operation, purchased in August 2009.

[2] S.M.A.R.T. (Self-Monitoring, Analysis and Reporting Technology; often written as S.M.A.R.T.) is a monitoring system for computer hard disk drives to detect and report on various indicators of reliability, in the hope of anticipating failures.

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Is the damage caused by high noise levels?

Extinguishing systems have two major sources of noise: the acoustical alarm devices used to warn people to leave the area before the agent is released, and the discharge of the extinguishing agent itself. In the second test Siemens decided to measure the effects on the HDDs when exposed to high noise levels.

According to standards and regulations, alarming devices for dry extinguishing systems must generate noise levels between 90 and 120 dB.[3] Electric alarm sounders are typically at the lower end of the range, and pneumatic ones at the upper end.

During dry extinguishing system discharges, high noise levels are produced when the agent flows through the nozzle into the protected area. For some applications the noise level can exceed 120 dB. This is true for inert gases as well as for chemical agents, and depends on various design factors as well.

Test setup: The figure above shows the test setup used to evaluate the noise sensitivity of the HDDs. The HDDs were placed and used in the same way as for the overpressure tests, and performance was measured in the same way.

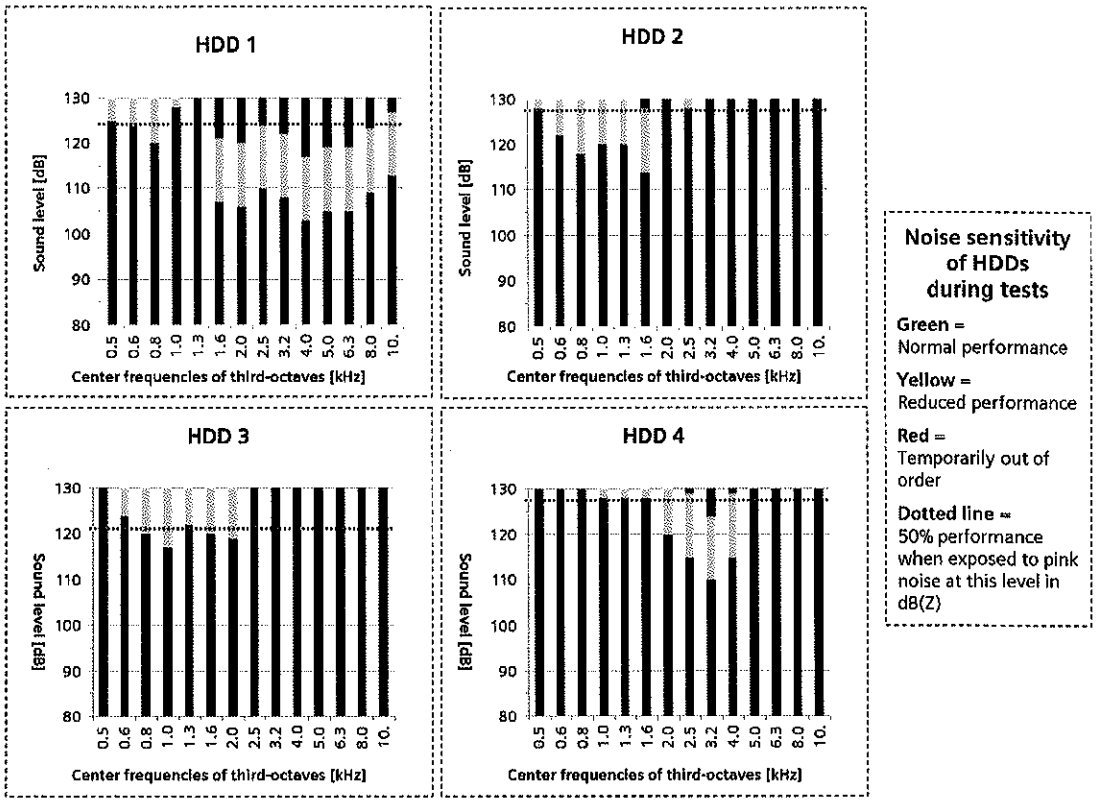
Placed at a distance of one meter from the HDDs, a sound generator with a loudspeaker created pink noise (broadband 500 Hz to 10kHz) and 1/3 octaves (353 Hz to 10 kHz). The noise levels were then measured by a sound level meter, at a close distance to the HDD.

The advantage of using a sound generator instead of a dry extinguishing system was the high controllability and reproducibility of the test conditions. Although sound generated by a dry extinguishing system shows the characteristics of white noise, pink noise was chosen for the tests so as to avoid damage to the loudspeaker from the high-frequency spectrum of white noise.

Since the HDDs were directly exposed to the noise source without being mounted in a rack or in a computer, the tests were conducted in the worst possible conditions for noise impact.

[3] Example given: EN 12094-12:2003 Fixed firefighting systems – Components for gas extinguishing systems – Part 12: Requirements and test methods for pneumatic alarm devices.

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The figure above shows at what sound level the performance of the HDDs were reduced (yellow). The test results showed that excessive noise, at a noise levels harmful to human health, can have negative effects on HDD performance which temporarily may cause periods where the HDDs are out of order (red). This level typically starts at 120 dB (at third octave level), but may for certain HDDs types and frequencies begin already below 110 dB.

Most of the HDDs were found to be sensitive to noise in the frequency range of 500 Hz to 5 kHz. As expected, some resonating frequencies were found to have an even stronger impact (not shown here).

Are the laboratory results transferable to actual extinguishing systems?

In order to observe the effects when exposed to full-scale extinguishing discharges, Siemens performed further tests using the same performance measurement setup and HDDs during actual extinguishing discharges.

A series of tests were conducted with the following Siemens extinguishing solutions:

- Sinorix 1230 (agent: FK-5-1-12 / 42-bar cylinder pressure)
- Sinorix 227 (agent: HFC227ea / 42-bar and 25-bar cylinder pressure)
- Sinorix N_2 (agent: Nitrogen IG100 / 300-bar cylinder pressure)
- Sinorix CDT – Constant Discharge Technology (agent: Nitrogen IG100 / 300-bar cylinder pressure / regulated valve)

Conclusion: As expected, some negative effects on HDD performance were observed. However, no loss of information or total destruction on the HDDs was found.

Sinorix Silent Extinguishing Technology

After concluding that high noise levels may cause damage to hard disk drives, Siemens initiated the development of a silent extinguishing technology. The goal of the development process was to create an extinguishing system operating at the same performance level as a conventional system, but with a significantly lower noise level that would not damage hard disk drives.

In a predefined reference room, calculations were made based on a targeted design concentration of the extinguishing agent in a given flooding time. The reference room had a volume of 5×5×4 meters (25 m^2 floor space, 100 m^3 volume) with an average reverberation time of 0.6 seconds in the frequency spectrum between 500Hz to 5 kHz. The extinguishing agent, nitrogen, was released into the room at a peak mass flow of 1.6 kg/s.

The following sections present the total noise level reduction potential calculated in our reference room. When all considerations were taken into account, the noise reduction potential was 41 dB. This is a significant reduction in noise level, which confirmed the success of the development process.

Using Sinorix Silent Nozzle lowered the noise level by 20 dB

Using Sinorix Silent Nozzle instead of a conventional nozzle typically reduced the emitted noise by approximately 20 dB in the relevant spectrum. A noise reduction of 20 dB is equivalent to a reduction of noise energy by one-hundredth, a significant reduction.

Using Sinorix CDT lowered the noise level by 8 dB

Using a regulated extinguishing system instead of an unregulated system also lowered the noise level. Our tests showed that an equalized mass flow over the discharge time led to a noise reduction of approximately 8 dB.

Room acoustic improvements lowered the noise level by 5 dB

Each room has its own acoustic fingerprint. This means that the noise absorption characteristics are dependent on the frequency spectrum. The reverberation time RT60 is the time needed to deplete the sound level by 60 dB, which is one millionth of the original level. A typical reverberation time for rooms with bare concrete or glass surfaces is 2.0 seconds; for offices it is around 0.5 seconds. When the reverberation time is cut by half, the noise level is lowered by 3 dB. Therefore, lowering the reverberation time of a room from 2.0 to 0.6 seconds would reduce the noise level by 5 dB.

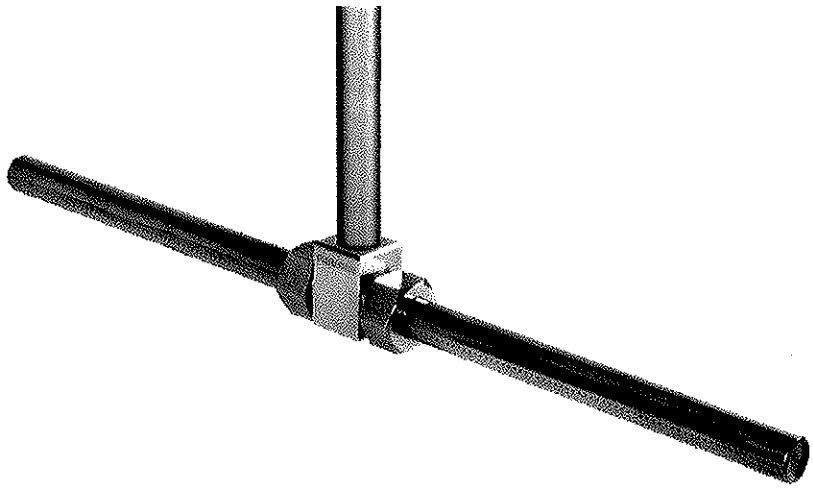
Extended discharge time lowered the noise level by 3 dB

Depending on local codes and practices, doubling the discharge time from 60 to 120 seconds can be appropriate for fire scenarios in data centers. The expected fire scenario in a data center is more likely to be a smoldering fire arising from the electrical equipment than a rapidly developing open fire. When the discharge time was doubled from 60 seconds to 120 seconds, the noise level was lowered by 3 dB.

Correct flow direction lowered the noise level by 5 dB

The flow direction of a nozzle pointing directly to the equipment enclosure (e.g. a storage system cabinet) might activate resonating frequencies and hence direct additional noise toward the equipment. When the nozzle was carefully positioned in relation to the sensitive equipment, the noise level was lowered by 5 dB.

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Sinorix Silent Nozzle

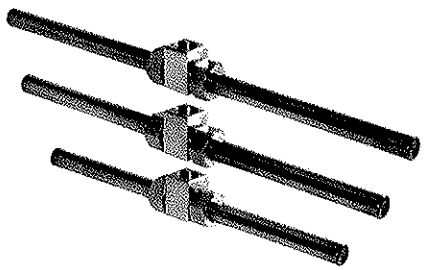
With Sinorix Silent Nozzle, the extinguishing process is designed in such a way that the noise level remains below the level found in tests to pose a risk to hard disk drives. Using Sinorix Silent Nozzle instead of a conventional nozzle typically reduces the emitted noise by 20 dB in the relevant spectrum.

The nozzle has a linear design that regulates the inert gas inflow via rows of tiny holes. This allows efficient distribution of the agent into the protected area, and at the same time provides the same efficiency as a conventional system. A patent has been filed for this linear design. In addition, the discharge of the agent, and hence the sound, is focused in a predefined direction, preventing additional sound-generated problems.

Usable with environmentally friendly and people-safe inert gases nitrogen and argon

Sinorix Silent Nozzle is especially developed for the use of Sinorix CDT with nitrogen and argon as extinguishing agents. Already present in our ambient air, nitrogen and argon present no environmental hazards. In addition, both agents offer excellent extinguishing properties. Using pure gases instead of a mixture of different gases also facilitates refilling because they are widely available.

The Sinorix CDT technology consists of a cylinder valve with a pressure-regulating function which discharges the gas into the flooding zone at constant mass flow throughout the entire flooding time. This eliminates the peak at the beginning of the discharge and thus lowers the maximum noise level.



Sinorix Silent Nozzles in different sizes

Sinorix Silent Nozzle comes in three different sizes: S, M and L

As the figure above shows, Sinorix Silent Nozzle is developed in three different sizes – small, medium and large – to better accommodate the required mass flow. The smallest nozzle is especially well suited for rooms with false floors or ceilings.

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Questions & Answers

Why should I protect my data center with a dry extinguishing system?

There is no question about the need for a dry extinguishing system to protect your valuable assets: the biggest risk is always the risk of fire. Siemens recommends installing a dry extinguishing system to protect your data center against the risk of fire.

Is the noise level dependent on the type of extinguishing agent?

It would be misleading or false to suggest that using a particular type of agent will solve the noise problem. The agent used in an extinguishing solution, per se, does not determine the overall noise level of the system. Several design factors influence the noise level, and every nozzle used to distribute the agent into the room produces sound energy independently from the type of agent used.

Are water mist systems good alternatives in data centers?

The extinguishing agent discharged in a dry extinguishing system is neutral to electronics and sensitive surfaces. In contrast, when a water mist system is discharged, a thin layer of water covers all surfaces, and harmful substances in the smoke may be deposited on sensitive surfaces. In addition, in an actual fire the inherent risk of spraying water in a data center may be increased due to the presence of smoke.

Will future solid state disks solve the problem?

When new technologies like solid state disks replace today's technologies, the problem of damage to noise-sensitive HDDs may disappear on its own. However, since our tests showed variances in the sensitivity of the HDDs tested, Siemens recommends contacting the manufacturer to verify the technology or get additional information.

Do fault-tolerant RAID systems solve the noise issue?

In many cases fault-tolerant data-storage systems such as RAID systems are used to improve the reliability and availability of data storage. RAID systems normally require HDDs to respond more quickly to read-and-write requests than conventional controllers. Noise disturbance to the HDDs might cause the RAID controller to disconnect the HDDs and declare them unreliable.

What is the correlation between room size and sound level?

The mass flow needed for a certain protection volume, and the sound energy density are scaling linear with the room volume. This means that the noise level is independent of the protection volume, and instead is primarily a function of nozzle acoustics, room acoustics, discharge time and mass flow. The flow direction may be an additional optimization lever, but only with local effect.

Is it better to use one large nozzle than several small ones?

As mentioned above, the noise level generated is primarily dependent on the mass flow. This means that one nozzle with an orifice of a particular diameter generates the same noise level as two nozzles with orifices of half that diameter.

Thus, careful placement of the nozzles in relation to the room's furniture is essential. Siemens recommends referring to the logarithmic scale. Doubling the noise energy means increasing the noise level by 3dB.

Can Sinorix Silent Nozzle be used in rooms with false floors or ceilings?

Ordinarily, false floors and ceilings are not separated acoustically from the room. The small version of Sinorix Silent Nozzle (SDN-S) has a dedicated drilling pattern to limit the gas flow to the horizontal plane, and thus is especially suitable for rooms with false floors or ceilings.

Abbreviations

CDT	Constant Discharge Technology
dB	decibel
EPD	electronic data processing
HDD	hard disk drive
Hz	hertz
kHz	kilohertz
mbar	millibar
RAID	redundant array of independent disks

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