United States Environmental Protection Agency
Office of Solid Waste and Emergency Response (5104)
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LIGHTNING HAZARD TO FACILITIES HANDLING FLAMMABLE SUBSTANCES

The Environmental Protection Agency (EPA) is issuing this *Alert* as part of its ongoing effort to protect human health and the environment by preventing chemical accidents. Under CERCLA, section 104(e) and Clean Air Act (CAA), EPA has authority to conduct chemical accident investigations. Additionally, in January 1995, the Administration asked the Occupational Safety and Health Administration (OSHA) and EPA to jointly undertake investigations to determine the root cause(s) of chemical accidents and to issue public reports containing recommendations to prevent similar accidents. EPA has created a chemical accident investigation team to work jointly with OSHA in these efforts. Prior to the release of a full report, EPA intends to publish *Alerts* as promptly as possible to increase awareness of possible hazards. *Alerts* may also be issued when EPA becomes aware of a significant hazard. It is important that facilities, SERCs, LEPCs, emergency responders and others review this information and take appropriate steps to minimize risk.

CHEMICAL SAFETY ALERT

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PROBLEM

Lightning strikes that hit equipment and storage or process vessels containing flammable materials can cause devastating accidents at refineries, bulk plants, processing sites, and other facilities. This alert is designed to raise awareness so industry can take proper precautions.

RECENT ACCIDENTS

In recent years, several accidents have occurred where lightning has struck facilities handling flammable substances, resulting in explosions and fires. In general, there was little or no information on the lightning protection used at these facilities, however, given what is currently known about lightning, these incidents may have been preventable.

In a 1996 incident, lightning struck a storage tank containing three to four million gallons of gasoline, causing a portion of the tank lid to shoot up and come down on its side into the tank. The gasoline stored inside did not spill out, but there was a massive fire that burned for 28 hours before being put out by firefighters. Firefighters sprayed water on 15-20 surrounding tanks to prevent another explosion; even so, the fire fatigued four nearby tanks. Although the explosion and fire caused no deaths or injuries, about 200 nearby residents had to be evacuated.

In a 1992 incident, lightning struck a fiberglass storage tank, setting off a series of explosions that released toxic fumes and spread thick smoke over town. More than 1,000 people were evacuated, and there were minor injuries, including nausea, skin irritation, and shortness of breath.

In a 1977 incident, lightning struck a roof tank containing diesel fuel. Roof fragments struck and ignited two other gasoline tanks; the tanks and gasoline were destroyed. Property and cleanup costs were eight million dollars.

HAZARD AWARENESS

Lightning strikes cause more deaths, injuries, and damage than all other environmental elements combined, including hurricanes, tornadoes, and floods. The National Fire Protection Association (NFPA) estimates there were 26,400 lightning-caused fires annually between 1989 and 1992; property damage during this time was estimated

to be in the billions of dollars. According to the Insurance Information Institute, five percent of all paid insurance claims were lightning-related. While all types of facilities should evaluate their lightning safety, storage tanks containing flammable substances may represent a special fire or explosion hazard in the event of a lightning strike; a spark, that might otherwise cause little or no damage, could ignite flammable vapors, resulting in a fire or explosion. Releases of toxic substances also have occurred.

Lightning is a form of static electricity; it has extremely high electrical potentials and energy and can generate extremely high temperatures. Lightning is a random, capricious event and not well understood. What is known is that lightning tends to strike the tallest object on the ground in the path of its discharge. Parts of structures most likely to be struck are those that project above surrounding parts, vents, edge of roof, wind sock, etc. The bolt generally follows a conductive path to ground. Lightning may enter a structure by striking it directly, by striking a metallic object extending up and out from the structure, by striking a nearby tree or other tall object and moving horizontally to the structure, or by striking overhead wires and being conducted into the structure by power lines. Lightning strikes vary in frequency depending on location. In general, according to the National Severe Storm Laboratory (NSSL), the U.S. mainland has a decreasing amount of lightning toward the northwest. Over the entire year, the highest frequency of cloud-to-ground lightning is in Florida between Tampa and Orlando. There are also high frequencies along the Gulf of Mexico coast westward to Texas, the western mountains, the Atlantic coast in the southeast, and inland from the Gulf. Regions along the Pacific west coast have the least cloud-to-ground lightning.

Hazard Reduction

Proper lightning protection provides a controlled path for the current to follow back to earth and minimizes the development of hazardous potential differences. It may not be possible to completely eliminate the possibility of damaging accidents caused by lightning, a random phenomenon. However, steps can be taken to minimize them. Facilities should determine an adequate level and type of protection and then regularly maintain and inspect the protection systems.

A low impedance path (e.g., lightning rod to ground) should be offered to prevent the lightning current from taking other possible destructive routes. Most metals are good electrical conductors for low impedance paths and unaffected by electricity flow. This path must be a continuous path from the ground terminal to the air terminal (lightning rod). This requires that metal parts be interconnected or bonded so that they maintain the same electrical potential. This prevents side-flashes or sparks over disconnected metal parts. Potential gaps between metallic conductors should be avoided especially where flammable vapors may escape or accumulate.

For tanks holding flammable substances, protection devices, such as air terminals (lightning rods), bonding and appropriate grounding systems, conductors (connects air terminals to grounding system), masts, overhead ground wires, and other types of protection, should be considered. The National Lightning Safety Institute (NLSI) recommends that connector bonding should be thermal, not mechanical, where possible. The NLSI also recommends frequent inspection and resistance measuring of mechanical connectors. The configuration of the grounding system is important and depends upon soil conditions, building construction, and the presence of other underground conductors. Grounding systems can be created with driven ground rods, plates, and perhaps a counterpoise (a buried cable encircling the site). Materials adequate to withstand lightning strikes should be used; specifically, use of low impedance materials (e.g. metals) is essential. The grounding system should be designed for a target resistance of five ohms/meter resistance or less.

Testing, inspection, and electrical continuity measurement should be a part of maintenance. Grounding cables connected to tanks should not be painted over, corroded, or contain items such as dirt or bugs that will create a path for lightning other than to ground. When checking tanks, put the ohmmeter - the electrical resistance meter - from cable to tank and note

the reading. The reading should be very low; a high reading requires cleaning of the connections.

Some tanks used for storage of flammable substances may be self-protecting from damage from lightning and may need no additional protection; such tanks would include metallic structures that are electrically continuous, tightly sealed to prevent the escape of liquids, vapors, or gases, and of adequate thickness to withstand direct lightning strikes.

Besides starting fires, lightning can also disrupt control systems and electrical circuitry more than two miles away. This can result in corrupted data, false signals, or immediate or delayed destruction of sensitive electronics that could cause an upset or release in your process. Ordinary fuses and circuit breakers are not capable of dealing with lightning strikes. Surge protection for sensitive electronics (such as process-control circuitry and related PC boards, computers, and other equipment) should be used. There are many types and manufacturers of surge-suppression equipment. The most cost-effective device should be carefully selected to handle the currents and voltages expected from a severe strike. Surge suppressors should be installed where they can be inspected easily and replaced when damaged by a severe strike. Several codes and standards for lightning protection may be consulted for specific guidance; examples of such standards are cited in the next section. Additional information also may be available from various organizations and publications.

Information Resources on Lighting Protection

Some references that may contain information about the hazards of lightning resulting in explosions and methods of minimizing these hazards are listed below. Regulations potentially applicable to facilities, and codes and standards that may be relevant are also listed below.

For more information consult the following:

Statutes and Regulations

Section 112(r) of the Clean Air Act focuses on prevention of chemical accidents. It imposes on facilities with regulated substances or other extremely hazardous substances a general duty to prevent and mitigate accidental releases. Accident prevention activities include identifying hazards and operating a safe facility.

EPA's Risk Management Program (RMP) Rule [40 CFR 68] is intended to prevent and mitigate accidental releases of listed toxic and flammable substances. Requirements under the RMP rule include development of a hazard assessment, a prevention program, and an emergency response program.

The Occupational Safety and Health Administration (OSHA) has the Process Safety Management Standard, which includes regulations on fire prevention.

Occupational Safety and Health Administration
Phone: (202) 219-8151 - Public Information
Web site: http://www.osha.gov

Codes and Standards

The American Petroleum Institute (API) has standards relevant to lightning protection at facilities.

American Petroleum Institute
1220 L St NW
Washington DC 20005
Phone: (202) 682-8000
Web site: http://www.api.org

Relevant API standards include:
API RP 2003 — Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents, fifth edition, 1991.

API PUBL 2210 — Flame Arrestors for Vents of Tanks Storing Petroleum Products, second edition, 1982.

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The National Fire Protection Association (NFPA) has lightning and flammable/combustible liquid codes.

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
Phone: (617) 770-3000
Customer Service: 1 (800) 344-3555
Web site: http://www.nfpa.org

Relevant NFPA codes include:
NFPA 30 — Flammable and Combustible Liquids Code, 1996.
NFPA 70 — National Electric Code, 1996.
NFPA 77 — Static Electricity, 1993.
NFPA 780 — Lightning Protection Code, 1995.
NFPA 921 — Guide for Fire and Explosion Investigations, 1995.
NFPA 1600 — Disaster Management, 1995.

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Underwriters Laboratories Inc. (UL) has standards for product safety.

Underwriters Laboratories Inc.
333 Pfingsten Rd
Northbrook, IL 60062
Phone: (847) 272-8800
Web site: http://www.ul.com

Relevant UL standards include:
UL 96 - Lightning Protection Components, 1994.

UL 96A - Installation Requirements for Lightning Protection Systems, 1994.

UL 198G - Fuses for Supplementary Overcurrent Protection, 1988.

UL 467 - Grounding and Bonding Equipment, 1993.

UL 525 - Flame Arresters, 1993.

UL 1077 - Supplementary Protectors for Use in Electrical Equipment, 1994.

UL 1449 - Transient Voltage Surge Suppressors, 1996.

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Organizations Dedicated to Lightning Issues

The Lightning Protection Institute (LPI) has endorsed official programs since the 1970s for the certification of properly installed lightning protection systems.

Lightning Protection Institute
3335 N. Arlington Heights Rd, Suite E
Arlington Heights, IL 60004
Phone: 1 (800) 488-6864 or (847) 577-7200
Web site: http://lightning.org

Relevant LPI standards include:
LPI-175 - Lightning Protection Systems Standard of Practice

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The National Lightning Safety Institute's (NLSI) mission is to improve lightning safety through various activities including establishing specific audit and certification protocols, as well as engineering site survey programs.

National Lightning Safety Institute
891 N. Hoover Ave.
P.O. Box 778
Louisville, CO 80027
Phone: (303) 666-8817
Web site: http://www.lightningsafety.com

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A list of firms providing lightning protection technologies can be obtained locally, through the Internet by using the search terms "lightning and protection", and through LPI, NLSI, or the United Lightning Protection Association (ULPA).

United Lightning Protection Association
P.O. Box 22683
Lake Buena Vista, FL 32830
Phone: 1 (800) 668-ULPA (8572)
The ULPA does not currently have a web page.

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FOR MORE INFORMATION...

CONTACT THE EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW HOTLINE

(800) 424-9346 OR (703) 412-9810
TDD (800) 553-7672

MONDAY-FRIDAY, 9 AM TO 6 PM, EASTERN TIME

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http://www.epa.gov/swercepp/