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TECH NOTE

Title	**Is Electrolyte Spill Containment Necessary for Vented Lead-Acid (VLA) and Vented Nickel-Cadmium (Ni-Cd) Stationary Batteries?**
Document No.	**TN-111819-1**

Revision History

Date	Revision	Change Description	Author(s)
11/18/19	0	Initial Release	JAB

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Is Electrolyte Spill Containment Necessary for Vented Lead-Acid (VLA) and Vented Nickel-Cadmium (Ni-Cd) Stationary Batteries?

Introduction:

The above question is frequently asked and often the answer is what seems to be the standard answer to every stationary battery question – it depends! Well, the purpose of this technical note is to give an honest answer, taking into consideration years of experience and perusal of many codes, standards, guides and practices. Some of these are enforceable by law and others are just plain common sense. Many of these requirements are referenced below and advice is given.

First of all, let's take a look at codes and standards. Often these terms are used interchangeably, this document will use the term codes. These are written by Codes and Standards writing agencies such as the National Fire Protection Agency (NFPA), the Institute of Electrical and Electronics Engineers (IEEE) and the International Codes Council (ICC). These "model" documents can then be adopted in whole or in part by local and regional entities such as federal, state, local governments and other Authorities Having Jurisdiction (AHJ). Often, local jurisdictions will make changes or amendments to the model codes or even not update codes to later versions in a timely manner and often codes can lag years behind. So use caution and check with the AHJ as to the particular building, electrical and fire codes that are applicable. If in doubt, use the latest issue of a particular code.

While most of the time these documents agree with each other, sometimes they don't. A former colleague used to say that "the nice thing about codes is that there are so many of them to choose from." A list of the most applicable codes applicable to batteries and spill containment is included at the end of this document.

Definitions.

Vented Lead-Acid (VLA) Battery.

A single or multiple cell battery which contains lead plates immersed in a liquid dilute sulfuric acid electrolyte. It is open to the atmosphere through a venting arrangement. If the battery unit container is ruptured below the level of the electrolyte, the electrolyte, which may contain lead, will be released from the battery. If the battery is overcharged an electrolyte mist can be expelled from the battery.

Vented Nickel –Cadmium (Ni-Cd) Battery.

A single or multiple cell battery with nickel and cadmium plates immersed in a liquid dilute potassium hydroxide electrolyte. It is open to the atmosphere through a venting arrangement. If the battery unit container is ruptured below the level of the electrolyte, the electrolyte, which may contain nickel and cadmium, will be released from the battery.

Stationary Spill Containment.

A method of containing and neutralizing an unintentional spill or leak from a stationary battery.
This is usually achieved by the use of a liquid tight containment barrier and electrolyte absorbent and neutralizing pillows. Please note that different types of pillow are required for lead-acid and nickel-cadmium batteries. Sulfuric acid must be neutralized by an alkaline based chemical where potassium hydroxide requires acidic based neutralizing.

Sulfuric Acid

Sulfuric acid in its pure form is known as oil of vitriol. It is an acid composed of hydrogen, sulfur and oxygen. The chemical formula is H_2SO_4. The Specific Gravity (SG) of pure sulfuric acid is 1.84 which is 1.84 times heavier than a same volume of pure water. For battery use, the acid is diluted with deionized or distilled water to a relatively low strength, typically 1.215.to 1.250 SG. Even at these low strengths sulfuric acid is very corrosive and can cause skin irritation and burns. Eye contact should especially be avoided. It also corrodes metal, concrete and stone.

Potassium Hydroxide

Aqueous Potassium hydroxide is a strong inorganic alkaline solution with the chemical formula KOH. In a solid form it is commonly called caustic potash. It has a SG of approximately 1.45. The electrolyte in Ni-Cd battery is a 30% aqueous solution of KOH which is corrosive and besides causing burns to skin and eyes it can corrode metal, concrete and stone.

What do the codes and standards say?

IEEE

IEEE has compiled a document titled IEEE 1578 – *IEEE Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management*.[1] The latest issue is the 2018 version. This is a pretty comprehensive guide to pill containment covering occurrences to mitigation methods. It also contains in Annex B a model code that can easily be adopted by an AHJ. Although this is a Recommended Practice and not a Code, it makes perfect sense and to ignore it is asking for trouble.

The following are some excerpts from IEEE 1578

Clause 4. Safety

"4.2.1 Absorption.

Absorption is the immobilization of electrolyte into an easily handled, solid material. Absorption materials can be loose (suitable for shoveling on top of a spill, especially one that is not contained) or in pillow-like mats (suitable for passive absorption of small spills less than 5 liters or for creating barriers/dams to limit the spread of spills). Some commercially available absorption mats also include neutralizer and may change color when they come in contact with electrolyte. Caution must be used with the latter due to concerns about possible off-gassing or misting inside a building (see below). Absorption material should be appropriate for the type of electrolyte being absorbed. The absorption material should be able to safely absorb and hold the electrolyte while it is removed from the location of the spill. Caution must be used with loose absorption material to ensure that its use does not create excessive dust."

"4.2.2 Neutralization.

Electrolyte can be acidic (for example, sulfuric acid inside a lead-acid battery) or basic (for example, potassium hydroxide inside a Ni-Cd battery). Neutralizer should be able to safely convert the electrolyte to a pH between 5.0 and 9.0."

"4.3 Heavy Metals.
When a battery container cracks or breaks and electrolyte is spilled, there is an additional hazard that lead particles and other heavy metals (e.g. antimony, cadmium, or selenium) may also be a part of the spill. Personnel should exercise caution, and be aware of these heavy metals' residue, and their associated health hazard. Single-use protective gear should be properly disposed of along with other contaminated materials. All other clothing should be decontaminated or properly discarded in order to abate the health hazards of exposure to heavy metals."

Clause 7. Introduction to spill containment and management

"7.1 General.
Spill containment and management issues are addressed differently based on how and when they occur. Compliance with appropriate government regulations for disposal and reporting is the legal obligation of the user. Each occurrence must address: containment, absorption and/or neutralization, and disposal. These activities should be performed by qualified and authorized individuals in accordance with all applicable laws, regulations and internal company policies."

"7.4.1.1. Individual Rack Containment.

Typically some locally adopted codes mandate individual rack containment and specify the dimensions. Individual rack containment consists of a barrier around the perimeter of a battery rack beyond the drip line. The interior of the barrier should be liquid tight.

The barrier should be conspicuous to avoid a tripping hazard. The barrier should be designed to last for the lifetime of the battery. The minimum volume to be contained is typically no more than 1% of the total in all of the battery containers, or the amount of free-flowing liquid electrolyte in a single container, whichever is greater."

Annex A of IEEE 1574 gives a method and examples for calculating quantities of acid or potassium hydroxide for hazmat reporting.
Annex B of IEEE 1574 details an example of a model code. Of particular interest is clause B.5 which states:
"The battery room or area shall be provided with an approved method to manage an electrolyte spill and prevent it from spreading to areas where it could pose a hazard to the facility, equipment, or personnel. The volume to be managed shall be 1% of the total in all of the battery containers, or the amount of free-flowing liquid electrolyte in a single container, whichever is greater."

In the USA there were three main bodies that issued model building and fire codes.
These were:

- The International Conference of Building Officials (ICBO) which published the Uniform Building Code (UBC).
- The Building Officials Code Administrators (BOCA) which published the National Building Code (NBC).
- The Southern Building Code Congress (SBCCI) which published the Standard Building Code (SBC).

In the late 1990's it was decided that it was time for these geographically diverse codes should be amalgamated and the International Codes Council was formed. In 1997 the ICC had completed the International Building Code. The above is mentioned because some spill containment requirements and manufacturers of spill containment equipment still refer to the legacy codes.

The International Fire Code (IFC)[2]

"Section 608.5 addresses Spill Control and Neutralization and states:
An approved method and materials for the control and neutralization of a spill of electrolyte shall be provided in areas containing lead-acid, nickel-cadmium or other types of batteries with free-flowing liquid electrolyte. For purposes of this paragraph, a "spill" as any unintentional release of electrolyte."

NFPA 1, Uniform Fire Code.[3]

Chapter 52 deals with Stationary Lead-Acid Battery Systems and the Scope (52.1) states:
"Stationary lead-acid battery systems having an electrolyte capacity of more than 100 gallons (378.5L) in sprinkled buildings or 50 gallons (189.33L) in unsprinkled buildings

used for facility standby power, emergency power or uninterrupted power supplies shall be in accordance with Chapter 52."

Chapter 52: Stationary Storage Battery Systems states that a VRLA battery system must satisfy seven (7) requirements for it to be in compliance with NFPA 1. Those seven require the batteries to have:

1. Safety Caps (must be Self-Resealing Flame-Arresting Caps)
2. Thermal Runaway protection
3. **Neutralization prevention capabilities on-site**
4. Ventilation
5. Signage within battery cabinet indicating relevant electrical, chemical, and fire hazard
6. Seismic braces in seismically active areas
7. Fire detection in battery system room

Item 3 above states that "Neutralization Equipment shall be available and capable of neutralizing a spill from the largest battery to a pH between 7.0 and 9.0 including but not limited to absorbent material, neutralizing chemicals, or a containment and removal system and a response plan and neutralizing material must be available on-site.

National Fire Protection Association (NFPA)

The NFPA publishes the National Electrical Code® NFPA 70®

Article 480 deals with storage batteries. It is pretty weak on battery spill containment and recently removed all references to that subject other than to refer to other codes

A practical point-of-view.

Since the liquid electrolyte used in VLA stationary batteries is corrosive and can damage metallic structure and leach into concrete floors some form of spill control and absorption should be used with any VLA battery system irrespective of size or volume of electrolyte. Codes tend to be written from a safety and fire protection perspective and address measures to mitigate hazards. However, take the following example: Say a battery cell/unit leaks for any reason, (and the author has witnessed several instances) and electrolyte leaks onto a concrete floor. This goes unnoticed for a period of time and the electrolyte eats into the concrete and the rack anchors. The concrete will start to disintegrate and any steel reinforcing will corrode and expand. The long term result may render the location contaminated and some major reconstruction may be necessary.

Summary.

Spill containment and electrolyte absorption and neutralization may be required to meet certain code requirements. Some regulated utilities such as electric utilities can claim exemption from a code such as the National Electrical Code NFPA 70, which states in Article 90.2(B)(5)b that "The NEC doesn't apply to installations under the exclusive control of an electric utility where such installations: "(b) Are on property owned or leased by the electric utility for the purpose of generation, transformation, transmission, distribution, or metering of electric energy."

References

1. IEEE 1578, *Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management*. Available from the Institute of Electrical and Electronic Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 1331, USA. www.ieee.org
2. The International Fire Code (IFC) is one of the many building codes published by the International Code Council. Codes may be obtained from their website oreder@ieeesafe.org
3. NFPA 1 Fire Code. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169. https://www.nfpa.org/customerservice.

Other codes that relative to VVLA and Ni-Cd batteries are:

IEEE Std 450™, IEEE *Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications*

IEEE Std 484™, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.*

IEEE Std 1106™, *IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications (ANSI)*

IEEE 1184-1994, IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems

IEEE publications are available from the Institute of Electrical and Electronic Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 1331, USA.

Bibliography.

IEEE 1184-1994, IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems

IEEE 484, Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications

IEEE 485, Recommended Practice for Sizing Vented Lead-Acid Storage Batteries for Stationary Applications

IEEE 1145, Recommended Practice for Installation and Maintenance of Nickel-Cadmium Batteries for Photovoltaic (PV) Systems

IEEE 1375, IEEE Guide for the Protection of Stationary Battery Systems

IEEE 1635/ASHRAE 21, Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications

UL 1973, Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications

UL Subject 2436, Outline of Investigation for Spill Containment for Stationary Lead Acid Battery Systems

UL 1989, Standard for Standby Batteries.