ALPHABET SOUP:
BATTERIES and CODES

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ABSTRACT

There are a whole host of government and national/international standards bodies' codes and recommended practices. Which ones do users have to follow? What aspects of Battery installation, selection, sizing, maintenance, and operation do they cover? Who enforces them? This paper attempts to give a broad overview of relevant documents, a basic understanding of their subject matters, and an idea of which officials might enforce which requirements.

Relevant enforceable Codes include the following (dependent on the installation type, and adoption and enforcement by local AHJs):

- BOCA
- DOT CFR 49
- EPA CFR 40
- OSHA CFR 29
- IBC
- IFC
- NFPA 1
- NFPA 13
- NEC (NFPA 70)
- NFPA 75
- NFPA 76
- NFPA 111
- NFPA 5000
- SBC
- UBC
- UFC

Relevant recommended practices include the following (individual industries may have practices even more relevant to their industry; for example ANSI T1 telecommunications standards):

- ANSI T1.311
- IEEE 450
- IEEE 484
- IEEE 535
- IEEE 937
- IEEE 1106
- IEEE 1145
- IEEE 1184
- IEEE 1187
- IEEE P1188
- IEEE 1189
- IEEE 1375
- IEEE P1491
- IEEE P1578
- IEEE P15??

Aspects of battery installations dictated by Codes include all or portions of the following (depending on the installation type, and adoption and enforcement by local AHJs):

- Acid and Lead Reporting
- Battery Disconnects and EPO switches
- Clearances / working space
- Compartmentation/Separation
- Fire Suppression Systems
- Flame Arrestors
- Grounding
- HazMat Storage
- HazMat Transportation
- Insulation/Separation
- Minimum Maintenance
- Neutralization and/or Absorption
- Spill Containment
- Racks and Trays (including seismic considerations)
- Safety and Signage
- Testing and Acceptance
- Ventilation and Temperature control

Additional aspects of battery installations covered by universal and industry-specific practices include (some of the aforementioned aspects covered by Codes are more completely covered in these practices too):

- Acceptance
- Alarming
- Charging
- Grounding
- Installation
- Maintenance
- Monitoring
- Selection
- Sizing
- Testing

Codes are adopted by governing jurisdictions (federal, state, county, municipality, etc.). Not all jurisdictions adopt all Codes, and the Code cycle (issue date) may be different from one area to the next. Some industries are given exemptions from certain Codes or provisions. The various authorities required to sort through this mess of Codes and make the final decisions about what applies are known as the Authority Having Jurisdiction (AHJ). These could include one or more of the following:

- Building Inspector
- Electrical Inspector
- EPA
- Fire Marshal/Inspector

This paper will expand on the Codes and AHJs to give the battery user a better understanding of how to be "compliant".

SPILL CONTAINMENT, VENTILATION, and NEUTRALIZATION

Codes covering spill containment, neutralization/absorption, and ventilation include: the IFC, the UFC, the UBC, NFPA 111, and the next issue of NFPA 1. These issues are too lengthy for this paper and methodologies will be covered in forthcoming editions of IEEE Par 1578 (spill containment), Par 15?? (ventilation — co-developed with ASHRAE and ASME representation), and ANSI T1.311 (Battery Room Environment).

HAZARDOUS MATERIALS REPORTING

The EPA has jurisdiction over a federal law requiring location reporting of hazardous materials (typically acid and lead) over a certain amount. The states and local jurisdictions determine to whom the reports must be made. Typically, the reports are submitted to the local fire departments or fire marshals, as fire departments usually have HazMat responsibility for a given jurisdiction. The law requires the reporting of amounts of acid (lead reporting minimum quantities vary by jurisdiction) in a given location which exceed 500 lbs. Most companies cleverly follow the letter of the law and report only sites with over 500 lbs. of acid in the batteries, computing the percentage of pure acid by weight in the electrolyte. Some jurisdictions have caught onto this practice and require the reporting of the weight of the electrolyte. Actual weights of acid, electrolyte and lead vary by manufacturer and by battery size and type, mostly due to differing jar sizes, specific gravities, and plate thicknesses. The user can obtain actual weights from the battery manufacturer. Often the information can even be found on the manufacturer's website. The following table can be used as a rough estimate, although the actual numbers used for submission should probably come from the manufacturers' information.

<table>
<tr><th colspan="5">Table 1, HazMat Weight Estimations for Lead-Acid Batteries</th></tr>
<tr><th>Battery Type</th><th>Specific Gravity</th><th>Electrolyte Weight</th><th>Acid Weight</th><th>Lead Weight</th></tr>
<tr><td rowspan="4">Flooded</td><td>1.215</td><td rowspan="4">5.0 lbs/100Ahr/cell
14.30 lbs/kW/cell</td><td>1.5 lbs/100Ahr/cell
4.2 lbs/kW/cell</td><td rowspan="7">15.0 lbs/100Ahr/cell
43.0 lbs/kW/cell</td></tr>
<tr><td>1.245</td><td>1.7 lbs/100Ahr/cell
4.8 lbs/kW/cell</td></tr>
<tr><td>1.280</td><td>1.9 lbs/100Ahr/cell
5.4 lbs/kW/cell</td></tr>
<tr><td>1.300</td><td>2.0 lbs/100Ahr/cell
5.6 lbs/kW/cell</td></tr>
<tr><td rowspan="3">VRLA</td><td>1.280</td><td rowspan="3">3.0 lbs/100Ahr/cell
8.6 lbs/kW/cell</td><td>1.1 lbs/100Ahr/cell
3.2 lbs/kW/cell</td></tr>
<tr><td>1.300</td><td>1.2 lbs/100Ahr/cell
3.4 lbs/kW/cell</td></tr>
<tr><td>1.325</td><td>1.3 lbs/100Ahr/cell
3.6 lbs/kW/cell</td></tr>
</table>

CLEARANCES

Note that certain industries (notably telecommunications and electric utility) are exempt from the National Electrical Code, although they try to follow it where applicable. Whether or not the exemption is applicable, and where the point of demarcation is located can be points of contention with a local Electrical Inspector.

Table 110.26 of the NEC specifies a 3 foot working clearance for most instances. For equipment that only has live parts on one side, 30" is still recommended for rear access. 30 inches is also the required working width. Overhead clearance is a minimum of 80" for headroom, where applicable.

In addition to Code requirements, IEEE Recommended Practices mention other space-related items that must be considered when placing batteries. These include space for battery hoists (when needed), maintenance space above batteries and when batteries are placed in cabinets or on shelves, and ventilation space around batteries. Most documents and manufacturers generally recommend at least 8 inches of top clearance for post maintenance (this would not be applicable for front-terminal batteries) and watering. Generally, at least ¼" to ½" of ventilation clearance is recommended between batteries.

Article 110.27 of the Code also requires guarding of exposed parts exceeding nominal 50 VDC, as well as warning signs.

FIRE SUPPRESSION SYSTEMS

NFPA 1, 13, 70, 76, and the forthcoming 5000; plus the IBC, IFC, UBC, and UFC; among many other documents, address fire suppression systems. The AHJ has the final decision on whether to grant exemptions for certain areas of a building, etc.

Properly designed and installed sprinkler systems will generally pass muster with almost any Fire Marshal. However, some industries and/or installations may not desire a sprinkler system or other forms of automatic suppression (foam, carbon dioxide, halon, etc.) because of the risk of service loss from a system failure or minor fire. Most of the Codes allow the Fire Marshal to grant an exception for telecommunications switching space; and as a consequence, most telecommunications battery rooms do not have automatic suppression systems. However, the granting of the exemption is still up to the AHJ. Use of flame-retardant battery jar materials and cables can help to sway a Fire Marshal if the user desires exceptions or alternatives to sprinklers. Dry sprinkler systems are an option that an AHJ may allow.

As noted above, there are alternatives to sprinklers. Halon is a CFC, and is being phased out for environmental reasons. Foam and carbon dioxide are also alternatives for automatic suppression. Each alternative has its pros and cons. In no case, even if an exemption is granted from automatic suppression systems, should a battery room be left without fire protection. The fire marshal will at least require portable extinguishers to be placed per Code requirements.

GROUNDING

The NEC requires DC systems to be grounded for personnel safety. Electric utilities do not ground their DC systems for reliability reasons. This is permissible because (as noted earlier), they are exempt from the NEC, and they only use qualified personnel to work on these systems. They do ground their battery stands and check for faults to ground from their battery system.

TRANSPORTATION

In the United States, there are Department of Transportation Regulations regarding the transport of "Hazardous Materials". Batteries fall under these regulations. The Code of Federal Regulations (CFR) Volume 49 spells out the requirements.

Batteries should be tested and assigned a UN number. This number specifies which regulations apply to that battery type. For example, the UN2800 designation ("non-spillable") for most VRLA batteries qualifies them for less strict regulation. In addition, manufacturers can test VRLA batteries to International Air Transport Authority (IATA) criteria to see if their batteries will qualify for air transport.

Regulations govern the types and qualifications of carriers, weights, the bill of lading, etc. The battery manufacturer specifies packaging, stacking, and loading criteria for the carriers.

New batteries or batteries to be re-used are classed slightly differently (from a hazardous materials perspective) than batteries headed for recycling.

MAINTENANCE

There is no code that specifies exactly which types of maintenance must be performed or its frequency. However NFPA 111 does require maintenance for battery systems, and gives suggested actions and intervals. Although IEEE 450 (flooded battery maintenance) is a recommended practice, the nuclear industry has adopted it as a standard, and the Nuclear Regulatory Commission enforces its "recommended" intervals and actions.

In addition to IEEE 450, the following recommended IEEE practices are applicable maintenance recommendations for various stationary battery types and industries: IEEE 937 (photovoltaic system lead-acid maintenance), IEEE 1106 (NiCad maintenance), IEEE 1145, (PV NiCad maintenance), IEEE 1184 (UPS battery maintenance), IEEE 1188 (VRLA maintenance), and IEEE 1491 (battery monitoring).

SAFETY and SIGNS

Safety work rules are covered in the OSHA CFR 29. The requirements in this large volume also address safety precautions. Warning signs for battery areas are covered by almost every Code listed in the bibliography. IEEE Recommended practices also give wonderful safety suggestions for those who work on or around batteries.

BATTERY DISCONNECTS and EPO SWITCHES

Article 645 of the NEC includes requirements for power disconnects for "Information Technology" space. Although you and I may consider IT equipment to be servers, storage, etc., the definition of Information Technology equipment is open to interpretation by the electrical inspector, building inspector, or fire marshal. Basically, for any electronic equipment, it is possible that the user may be required to place battery disconnects and/or an "Emergency Power Off" switch. Even those industries exempted from the Code may be subject to local regulations that override the Code.

Many locations are required to have EPO switches for the fire department to use in case of an electrical fire. This one switch typically (by electric solenoids) opens the commercial AC breaker(s), and the standby/emergency engine(s) breaker(s). If there is a UPS, it may also open the UPS output breakers.

For DC systems, it is a little tougher. Because DC (unlike AC) has no zero crossing to help extinguish an arc, large DC breakers are typically physically larger than their AC counterparts of similar amperage. An additional concern with breaker (or disconnect contactor) sizing for batteries is the high short circuit currents of which batteries are capable. Because of this, for larger DC systems with multiple strings in parallel, usually individual string disconnects are used instead of one large load disconnect, since in some cases it is impossible to buy a disconnect with a high enough K.A.I.C. rating (see IEEE 1375 for more information on battery protection devices) to handle the short circuit current of all the strings.

COMPARTMENTATION

The various Fire Codes require larger battery areas to be separated by a 1-hr or 2-hr fire rated wall. The quantity of batteries is specified as gallons of electrolyte in the Codes, and varies by Code (from 50 gallons up to over 1000 gallons). The Fire Marshal can inform the user of which Code is applicable in that area. While some codes specifically exempt VRLAs, others leave it open to the interpretation of the AHJ.

FLAME ARRESTORS

NEC Article 480 requires flame arresting vents. This is not usually an issue, since almost all battery manufacturers incorporate them into their designs.

HAZMAT STORAGE

The Building Codes, Fire Codes, the NEC, and the EPA (CFR 40) all have regulations governing the storage of hazardous materials, including batteries. Generally, the areas and/or buildings are classified based on usage and what is stored there. From these classifications, the regulations follow.

INSULATION

Article 110.27 of the NEC requires guarding of exposed parts exceeding nominal 50 VDC, as well as warning signs. The NEC requires special separation and insulation for battery strings whose voltage exceeds 250 V. In some cases, the NEC requirements for greater than 250 V can be interpreted by an AHJ as requiring mid-string maintenance disconnects (sectionalizing a battery). The NEC also requires that even if battery racks and trays are made of metal, that the batteries sit on a non-conductive surface (that must be more substantial than paint). This is sometimes enforced, and as noted previously in this document, some industries are exempt.

SEISMIC CONSIDERATIONS

Racks, trays and batteries are required by Building Code to be seismically braced for the Earthquake Zone into which they are placed. Earthquake Zones and tests are specified by the Uniform Building Code. California has even stricter requirements.

TESTING and ACCEPTANCE

There are no codes that specify or require testing and acceptance, except for IEEE 535 (which only applies to nuclear generating stations). However, there are several excellent IEEE recommended practices on the subject: IEEE 484 (flooded lead-acid installation), IEEE 937 (PV lead-acid installation), IEEE 1106 (NiCad testing), IEEE 1145 (PV NiCad installation), IEEE 1184 (UPS battery installation), and IEEE 1187 (VRLA installation).

CONCLUSION

Which Codes and Regulations apply is a matter of local adoption. The Federal Codes will apply everywhere. For application of the NEC, consult your Electrical Inspector. For application of Fire Codes and other NFPA Codes, consult your Fire Marshal. For application of the building codes, consult your Building Inspector. Note that some Codes will no longer have future cyclical revisions, as their sponsoring organizations are now supporting other Codes. For example, BOCA (publisher of the National Building Code), the SBC, and ICBO (publisher of the UBC) now support the ICC Codes. The Western Fire Chiefs' UFC is being folded into NFPA 1, etc. However, depending on your local jurisdictions, the older Codes may apply.

REFERENCES

Acronyms

AC	Alternating Current
A-hr	Ampere-hour
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigeration, and Air-conditioning Engineers
ASME	American Society of Mechanical Engineers
BOCA	Building Officials and Code Administrators
CFR	Code of Federal Regulations
DC	Direct Current
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
EPO	Emergency Power Off switch
HazMat	Hazardous Material
IATA	International Air Transport Authority
IBC	International Building Code
ICBO	International Conference of Building Officials
ICC	International Code Council
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
IFCI	International Fire Code Institute
IT	Information Technology
K.A.I.C.	kilo-Amps Interrupt Current rating
kW	kiloWatts
lbs	pounds
NEC	National Electrical Code
NFPA	National Fire Protection Association
NiCad	Nickel-Cadmium battery
NRC	Nuclear Regulatory Commission
OSHA	U.S. Department of Labor Occupational Safety and Health Administration
PV	Photo-Voltaic
SBC	Standard Building Code
SBCCI	Southern Building Code Council International
s.g.	specific gravity
T1	Telecommunications standards committee 1
UBC	Uniform Building Code
UFC	Uniform Fire Code
UPS	Uninterruptible Power Supply
U.S.	United States
V	Volts
VRLA	Valve-Regulated Lead-Acid battery
WFCA	Western Fire Chiefs Association

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