SAFETY COLLABORATIVE

ENERGY STORAGE SYSTEM SAFETY

Documenting and Validating Compliance with Codes and Standards

Introduction

Energy, environmental, and economic challenges are spurring more widespread consideration and use of energy storage systems (ESSs), which in turn are driving increased development of new ways to store energy electrochemically, mechanically, and thermally. These new methods necessitate an increased focus on ensuring that public health, safety, and welfare are not adversely affected—something that has been addressed for many years through codes, standards, and regulations (CSRs)[1]. CSRs provide requirements that establish a basis for determining if an ESS is safe, whether electrochemical, mechanical, or thermal and regardless of the range of ESS applications, energy capacities, physical sizes, location, or number installed at any given site. The key to achieving desired safety goals, as memorialized through CSRs, is through documenting and validating compliance with applicable CSRs. The process of documenting and validating compliance, which is a key component to the initial approval as well as continuing acceptance of an ESS installation, is generally called *conformity assessment*.

Conformity Assessment

Conformity assessment first involves the proponent of an ESS or a designated agent(s) for the proponent documenting compliance with adopted CSRs[2] and then applicable authorities having jurisdiction (AHJs) validating that the CSR criteria they have adopted have been satisfied. This ensures that the expected outcomes as intended through the CSRs are achieved and, on that basis, the safety-related performance of an ESS can be trusted.

> ***Conformity Assessment***
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> ***Activities associated with documenting and verifying the degree to which applicable criteria in codes, standards, and other adopted documents are satisfied as evidenced through testing, certification, quality assurance, calculations, simulation, inspection, field evaluation, and other related activities.***

Proponents interested in deployment of ESS (e.g., designer, manufacturer, integrator, owner, etc.) are responsible for documenting that what they intend to implement complies with the adopted CSR criteria, which as noted before are intended to serve as a basis

[1] Codes, standards and regulations in the context of this document should be considered minimum requirements.

[2] See *Development and Adoption of Codes and Standards, 2018* (PNNL SA 136683/SAND2018 8857 M)

for determining what is and is not safe. The adopting entity/AHJ (e.g., state or local public safety agency, utility, insurance carrier, etc.), or a third-party they have approved to act on their behalf, has the authority to validate that what is proposed complies with the CRSs. This authority would include, for instance, a review of construction plans and specifications, application and use of third-party testing and listing information, inspections, and/or conduct of field tests and evaluations to ensure compliance is achieved.

Conformity assessment of ESS safety-related performance will generally include the following participants, each playing important roles in documenting and validating compliance with adopted CSR:

- ***Manufacturers of an ESS or components associated with an ESS***
- ***Accredited third-party testing laboratories and certification entities***
- ***Entities that accredit third-party testing laboratories and certification entities to applicable standards***
- ***Designers, installers, contractors, utilities, building owners/developers, and others involved in the planning and execution of the installation of an ESS***
- ***Insurance carriers, accredited third-party field evaluation or inspection agencies, registered design professionals, code officials, fire officials, accredited field evaluation bodies, electrical inspectors, building owners, and utilities who are involved in review and approval***

Those responsible for documenting or verifying compliance with CSRs may rely on services provided by third parties, such as testing of products by an approved third-party testing entity, listing and labeling (e.g., certification) of products by an approved follow-up inspection agency, field evaluations by approved third parties or plans, specifications and/or calculations prepared by a registered design professional. The need for a third party to be engaged in documenting or verifying compliance with CSRs is generally dependent on the nature of the CSR requirement under review.

When a requirement is simple and easily assessed (e.g., a dimension, liquid capacity, etc.), those documenting or verifying the requirement has been satisfied can do that themselves with no need for additional help (i.e., first-party conformity assessment). An example of such a requirement is a limit on the amount of electrolyte in a flow battery or thermal storage tank (e.g., “shall not exceed *X* gallons”) in a particular ESS installation. Clearly, no additional assistance or information would be required for anyone to document or validate compliance (other than having to determine the volume of the battery or storage tank).

When those verifying compliance need additional information, data, and/or assistance and are willing to accept what is prepared by the proponent of an ESS or an ESS installation, then acceptance only needs to involve those two entities (e.g., second-party conformity assessment). In effect, the AHJ may not be readily able to verify compliance as with a first-party situation but is willing to accept the proponent’s documentation (e.g., data, calculations, etc.) at face value. In this situation, those evaluating what is submitted by an ESS proponent may also request additional information and/or clarifications. They may also decide after review to not accept what is submitted and seek additional help from an independent accredited third party.

In many cases, compliance with the provisions in CSRs cannot be evaluated through a first-party process, and the AHJ may not be willing to accept documentation by the ESS proponent (e.g., second-party documentation that can also be considered self-certification). In that situation, an independent third party is retained by the ESS proponent and possibly another is retained by the AHJ. Third-party conformity assessment involves an independent entity approved by the AHJ that does testing, field evaluation and/or certification on behalf of a technology proponent, who then uses the result as a basis for documenting conformity with the codes and/or standards applied by the third party during its activities. It is important to note that third-party conformity assessment can be performed at the location where an ESS is manufactured and focus only on the acceptability of the ESS itself. That does not address the acceptability of the installation of the ESS, which must be evaluated separately by the AHJ or their designated agent(s) at the point of installation. If the ESS itself is of a size or type that does not lend itself to an assessment at the point of manufacturer, then a field evaluation of the ESS can be performed by an accredited third party. This can be the case with many larger “one-off” type systems where the ESS is created at the installation site and thus the ESS itself and the installation must be evaluated at that point (e.g., in the field).

It is important to note that were conformity assessment occurs at the point of manufacture of an ESS or ESS component an approved third party would conduct testing to validate compliance with standards applicable to the ESS or ESS component and then the same or another approved third party would conduct follow up inspections of production to validate that continued production was consistent with the ESS or ESS component that was found to comply with the applicable standard(s).

Any assessment of an ESS must consider the CSR provisions and includes determining what information is required; the associated metrics; the basis for measuring and reporting outcomes; and the testing, inspection, and review by appropriate entities. For example, a particular standard might establish a requirement that under a specified load a mechanical ESS either not fail or if it does fail that specific components of the ESS be contained. AHJs are not in a position to conduct such a test on an ESS, and proponents of such an ESS would likely consider having each and every AHJ conduct such

a test (even if that were possible) an unreasonable burden. In this case, the ESS proponent would retain the services of a third-party testing agency to run the tests outlined in the relevant standard(s) and provide test data that documents that the provisions in the standard(s) were satisfied. If the requirement in a standard were related to a specific metric, then relevant test data would be used to report the outcome of that metric.

After evaluation and/or testing of an ESS or ESS component as covered above is conducted, it is necessary to facilitate the application of those test results to continued production of the ESS or ESS component. This eliminates the need to test each and every ESS or ESS component, which would clearly be burdensome and cost-prohibitive. To allow the application of the evaluation and/or testing to all subsequent ESS or ESS components produced, the proponent (typically the manufacturer) can retain a third party to monitor continued production and document and validate that continued production is carried out in a manner identical to the ESS or ESS component that was previously tested. This process is associated with listing and labeling (e.g., certification), is conducted by a third-party entity, and results in the mark of that entity being applied to all continued production of the ESS or ESS component.

As noted above, if the size or type of ESS precludes testing and listing and labeling of the entire ESS or the ESS is “one-off” or unique, then a field evaluation may be conducted by a field evaluation body (FEB). While this may involve the application and use of tested and listed and labeled components, the goal is to assess the safety of the entire ESS in the field because it has not been evaluated at the point of manufacture because it is really manufactured in the field (e.g., point of application). Such an assessment will use adopted CSR as a metric for safety but will also include consideration of additional criteria such as National Fire Protection Association (NFPA) 791 or SPE-1000 in guiding how the ESS is evaluated during the field evaluation.

Field Evaluation Bodies (FEBs) provide this service through non-destructive testing and evaluation of the equipment. AHJs make the final decision on accepting FEB reports and the acceptability of installed equipment. Some jurisdictions maintain lists of acceptable FEBs, and others rely on FEBs accredited by accreditation bodies such as the International Accreditation Service.

The AHJs who are responsible for validating what is adopted conduct the necessary activities to ensure compliance is achieved (e.g., first party as mentioned above), or they rely on the work of the technology proponent (e.g., second party) or approved third parties, or some combination of both. Note that when AHJs rely on third-party information as a basis for documenting CSR compliance, they are essentially deferring their authority to those entities (e.g., trusting the information they provide in lieu of conducting the same or similar activities on their own). For this reason, AHJs are given the authority to approve third-party entities. Rather than subject third parties to review by numerous AHJs, international standards cover how such entities should be evaluated (such as testing, follow-up inspections, listing and labeling, field evaluation, etc.). There are also entities that exist solely to validate that a third-party entity continue to satisfy the conditions in the standards that apply to the role they play in conformity assessment. In short, those third-party entities participate in a process that certifies their ability to perform the services (e.g., testing, listing, etc.) on behalf of those needing to document or validate compliance with CSRs.

To summarize this process for a particular ESS or ESS component, safety standards, such as UL 9540 applicable to an ESS or ESS component standards such as UL 1973 for batteries or UL 810A for capacitors, are used to evaluate the ESS or ESS component. Satisfaction of the provisions in the standard and/or performance in relation to relevant metrics in the standard would be documented through third-party testing and then listing and labeling of the ESS or ESS component or through field evaluation. This documentation can then be used by the ESS proponent to document that what is manufactured and delivered for installation at a particular site is safe (assuming the applicable CSRs have been adopted and are used as a basis for approval). Similarly, an AHJ can use the test reports and listing and labeling of the ESS or ESS component to verify compliance with their adopted CSRs.

The listing and labeling of an ESS and/or ESS component document compliance with specific standards and/or their performance to one or more metrics. Listing and labeling do not directly document the acceptability of a particular installation, application, or use in the built environment, although a listing and labeling may provide limits to the application and use of an ESS or ESS component.

A simple example is using an ESS that is tested, listed, and labeled as being safe in accordance with an applicable standard covering portable ESS but is permanently installed and used inside a building. A more complex example is the application and use of multiple ESSs at a building site—each ESS would be deemed acceptable if tested, listed, and labeled or field evaluated to adopted standards. While each would be considered safe, they all still need to be installed in accordance with adopted CSRs in relation to each other and to the built environment surrounding them. Of note is that some ESS performance metrics determined through testing to adopted standards may need to be applied in documenting and validating the ESS installation in related to adopted CSRs. As previously noted, in some instances a field evaluation will be appropriate where the ESS may not have been tested, listed and labeled. Criteria exist that guide such evaluations with the results being applied to document the safety of an ESS, including the installation of the ESS.

With the documentation and validation of an ESS or ESS component as described above completed, the installation and application of the ESS or ESS

component within the built environment must be documented and verified relative to adopted CSRs.

These CSRs will generally include but are not limited to the International Fire Code of the International Code Council and NFPA 1 and 70 codes and 853 and 855 standards (see references below) as adopted by relevant AHJs. Beyond initial design and installation, these include ensuring that the ESS is commissioned, operated, maintained, repaired, refurbished, and eventually decommissioned as covered in the adopted CSRs. As noted above, while there are a number of different adopting entities and mechanisms for adoption, each of which may have the authority to develop its own unique requirements, participation in development of standards and model codes established and maintained by standards development organizations and then reliance on the outcome of that process eliminate what could be a complex and non-uniform mixture of CSRs throughout the U.S.

Conformity Assessment for an ESS—An Overview

1. ***During R&D, the "subject" (e.g., components of an ESS or a complete ESS) is tested by the manufacturer to determine if compliance with applicable safety standards is achieved and, where applicable, the value of relevant metrics as established by applicable standards is measured and reported.***
2. ***As R&D proceeds, the subject may be modified and then retested by the manufacturer to ensure that compliance and the desired outcomes associated with relevant metrics are secured.***
3. ***Pursuant to step 2 above, a determination is made to have the subject tested, listed, and labeled or field evaluated by an accredited third-party testing laboratory that then tests the subject and issues a report of findings. If the findings indicate non-compliance or values are not as desired, then the subject would be re-evaluated or re-designed and re-tested (although step 2 is intended to minimize this occurring).***
4. ***If the subject is an ESS, then the manufacturer will produce the ESS and involve a third-party agency in field evaluation or listing and labeling the ESS. If the subject is an ESS component, then the entity using the component (e.g., ESS manufacturer or integrator) may need to secure additional testing or assessment from a third party to document that the assembly of components as an ESS is acceptable or a field evaluation of the ESS is undertaken where it is not tested***
5. ***Those specifying and wanting to install an ESS supply documentation to the AHJ that includes relevant testing and listing and labeling or field evaluation information that the subject meets relevant standards. In addition, they prepare and submit plans, specifications, calculations, and other data documenting compliance with CSR applicable to the ESS installation to the AHJs having oversight for the installation.***
6. ***Those having jurisdiction over the installation (e.g., AJHs) conduct necessary inspections to determine that the approved plans and specifications are being satisfied, the ESS is installed in accordance with the conditions of the listing and, where required by the adopted codes and standards, may oversee the commissioning of the system or conduct periodic inspections during the life of the system.***

Documentation of compliance with adopted CSRs is initiated by the proponent of an ESS installation (e.g., owner of the ESS and/or the facility or property where it is to be installed) or its designated agent(s) (e.g., engineer, integrator, etc.). Because CSRs would adopt by reference safety standards applicable to the ESS or its components, documentation needs to include reports, listings, etc. from an approved agency, such as a third party acceptable to the AHJ, indicating compliance with the applicable ESS or ESS component standards. Documentation also has to address the acceptability of the ESS installation in relation to the environment (e.g., building, facility, property, etc.) in which it is to be installed. Such documentation includes, but is not limited to, plans, specifications, calculations, and other information showing that the criteria in the adopted CSRs were satisfied. Those criteria and documentation address issues such as siting and location, whether the ESS is new or an existing system being refurbished, ventilation and thermal management, interconnection with other systems, fire and smoke detection and prevention, and signage. That documentation is then reviewed by the applicable AHJ(s) and approved if found to effectively document compliance. If the documentation is found unacceptable, then the applicable AHJ notes any deficiencies and returns it to the proponent/applicant for correction as a condition for approval.

Once approval is secured, the installation can begin and the AHJ(s) can schedule inspections to ensure that the ESS that was noted on the approved plans and specifications was found at the site under review and that it was installed in accordance with those approved plans and specifications. Where the adopted CSRs require testing or commissioning, the AHJ(s) also witness those activities or require a report on the outcomes before issuing a final approval. Based on the availability of testing, listing and labeling information on

the ESS, field evaluation may also be initiated during and/or at the completion of the installation.

When the ESS technology is ahead of the provisions in CSRs or the installation proposed is not specifically covered in CSRs, the process of conformity assessment can be a little more complicated. Specifically, unlike the situation above where CSRs exist and provide a basis for documenting and validating safety of the subject or its installation, the rules may not yet be established or what rules exist cannot be directly applied to the needed task.

Until criteria are available and adopted, each ESS or ESS component and/or its intended installation may have to be assessed based on a comparison to similar technologies already covered in adopted codes and standards. Generally called “alternative means and methods,” CSRs generally have a provision that essentially states “if what you want to do is not specifically covered in the CSRs, then you can document compliance on the basis that what is being proposed is no more hazardous nor less safe than something that is covered in the CSRs.” This process can include onsite in situ testing of each installation (e.g., field evaluation) and/or submission of documentation validating equivalency with the intent of existing CSRs. For this reason, updating standards and model codes to address new ESS technologies and safety-related issues and supporting their timely adoption are key.

Whether documenting or verifying compliance with CSRs, the focus is on the safety of the system components; the system as a whole; the system installation and commissioning and its operation; and any repairs, additions, or renovations; and system decommissioning.

Summary

As with all prior and future technologies used in the built environment, ESS can provide value as long as 1) the technology and its application and use do not compromise public safety and 2) if a safety incident occurs, the situation can be addressed in a timely manner by system operators and first responders. In the absence of criteria to document and validate the safety of an ESS and its installation and an infrastructure to develop, adopt, and apply the criteria, it is impossible to uniformly and confidently determine what is and is not safe and to ensure that safety on an ongoing basis. In addition, while some involved in ESS development and deployment are focused on “doing the right thing” to document and ensure ESS safety, others may have other priorities. This situation can lead to safety-related events that can have a negative effect on the entire ESS market and/or create an atmosphere where AHJs, insurance companies, first responders, and others believe CSRs need to be more conservative in their requirements and/or the administration of those requirements.

Once CSR criteria are established and adopted, a system focused on conformity assessment that involves all stakeholders is needed to ensure those criteria are satisfied and consequently the expected safety of an ESS installation is achieved. That system has numerous components, each of which is important singularly and in the aggregate. If any one of those components (e.g., safety testing, product certification, field evaluation, documentation of compliance with installation, commissioning and use requirements, the review and approval of plans and specifications, the initial inspection of the installation or ongoing maintenance of required safety systems) fails, then the probability that an incident with safety implications increases. Another ongoing challenge is, and will continue to be, keeping CSRs updated in response to new ESS technologies, new ESS installation scenarios and applications, and the safety lessons learned from existing installations over time.

Resources

Additional information about conformity assessment can be secured from the sources listed below. Note that this list is not intended to represent all possible sources of information on this subject.

1. A2LA – www.a2la.org
2. CSA Group – www.csagroup.org
3. DNV GL – www.dnvgl.com
4. FM Global - www.fmglobal.com
5. IAS – www.iasonline.org
6. ICC – www.iccsafe.org
7. Intertek – www.intertek.com
8. NAVLAP – www.nist.gov/nvlap
9. NFPA – www.nfpa.org
10. UL – www.ul.com

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Collaboration

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