U.S. Department of ENERGY | Office of Environment, Health, Safety & Security

Operating Experience Level 3

OE-3: 2025-01 **January 2025**

Use of Cast Iron Fittings in Credited Fire Protection Systems

PURPOSE

This Operating Experience Level 3 (OE-3) document raises awareness of potential vulnerabilities with certain safety-class or safety-significant Structure, System, and Component (SSC) installations containing cast iron. Of note are recent examples of cast iron fittings installed in credited Fire Suppression Systems (FSSs). This document recommends actions to consider during the design, procurement, installation, and operation of such systems that are credited as safety significant or safety class. While this OE-3 focuses on FSSs, there may be other applications where cast iron materials are utilized, such as drainage, sanitary, air, water, and gas piping systems. Some of the information in this OE-3 could be helpful in informing if those systems warrant further attention.

BACKGROUND

Water-based automatic FSSs are installed according to the consensus standards of the National Fire Protection Association (NFPA), specifically NFPA 13, *Standard for the Installation of Sprinkler Systems*. This standard allows the use of cast-iron fittings if they meet testing protocols, become listed by a testing laboratory, and are installed in accordance with the standard. NFPA 13 also allows other materials such as malleable iron, steel, copper, chlorinated polyvinyl chloride (CPVC) plastic, bronze and stainless-steel fittings, provided they are listed. Sprinkler systems are normally installed to a contractor's preferences unless the design specifications call for something specific. DOE Standard 1066-2023, *Fire Protection*[1] provides guidance for implementing design and operational requirements for new safety significant and safety class fire protection systems. Starting with the 2012 version of DOE-STD-1066, Appendix A has recommended that new installations be used without cast iron fittings (§A.2.4.1.1). Cast iron fittings can fail in a brittle manner and corrode which could affect the reliability of the system during a seismic event due to a failure potential. However, the standard does not ban cast iron fittings for such systems. They are still allowed when supported through appropriate engineering analysis.

OPERATIONAL HISTORY

The Defense Nuclear Facilities Safety Board (DNFSB) April 2024 letter[2] to the Secretary of Energy identified two separate cases where cast iron fittings were installed in FSSs counter to DOE guidance. The letter also cites documents that discourage their use such as DOE-STD-1066-2023, DOE seismic guidance in DOE/EH 0545, *Seismic Evaluation Procedure for Equipment in U.S. Department of Energy Facilities*[3], and the industry-wide Electric Power Research Institute (EPRI) Report 1019199, *Experience-Based Seismic Verification Guidelines for Piping and Tubing*[4].

Although most of the systems in the EPRI reports are not seismically qualified, they still show the brittle nature of cast iron as a weak/failure point (see Figure 1), more vulnerable than components made of more ductile material such as steel.

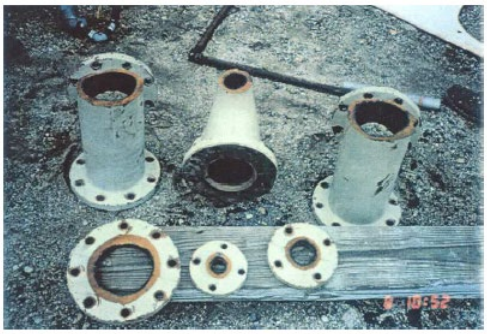

FIGURE 1 CAST IRON MATERIAL FAILURES[4]

Generally, across the DOE complex, FSSs have been installed in compliance with NFPA 13. This code has been in existence since 1896 and is used worldwide for ensuring fire suppression systems are installed to protect people and property. Issues tend to arise due to evolving conditions over the life cycle of the facility, as described below:

When changes to a building occur, the suppression system may need to be reconfirmed to be suitable for any new hazards introduced. Additionally, as facilities and systems degrade over time, system verification and validation can become more complex to the point that system replacement rather than maintenance may be necessary.

Within DOE, when a modification is made within a building that requires a revision to the Hazard Analysis, the FSS may be relied upon to perform its safety function in a manner that was not previously evaluated. This could include performing its safety function during and after a seismic event.

When a new FSS is designed at a DOE facility, it is required to follow DOE Order 420.1C, *Facility Safety*. The flow-down requirements then extend to the use of National Consensus Codes and any other DOE requirement deemed applicable.

Even when a consensus standard allows the use of a specific material, there may be additional DOE guidance for credited systems, such as in DOE-STD-1066-2023, that should be considered and flowed down into procurement and construction specifications. In the case of cast iron fittings, FSS installers may be so accustomed to installing them, these components may inadvertently find their way into a project, whereas the specification and/or construction requirements call for a different material such as malleable iron or carbon steel.

RECOMMENDATIONS

1. Ensure specifications for FSSs properly flow down from the requirements documents to the installation of the systems in the field.

Engineering, procurement, construction, and quality organizations should pay close attention to specifications for FSSs to ensure that the proper requirements flow down, construction submittals accurately reflect materials, and the proper components are installed. This is not only critical for FSSs, but any engineered system that has specific requirements in the design that must be brought forward to procurement and construction. For existing systems, ongoing surveillances and records reviews by Cognizant Systems Engineers should be used to identify whether cast iron components were installed counter to requirements from specifications, calculations, safety analysis, etc. This is particularly important for FSSs that serve a post-seismic function and were constructed prior to DOE-STD-1066 discouraging the use of cast iron fittings in 2012. In any case, if the materials are found to counter the requirements, sites must follow applicable site/facility procedures.

2. Ensure the use of cast iron fittings in new FSSs is supported by engineering analysis.

DOE-STD-1066-2023, Appendix A, does not recommend using cast iron fittings for new systems but does provide an alternative as part of manufactured assemblies, such as a check valve or gate valve. Footnote 102 in DOE-STD-1066 provides additional information, stating:

> *"Fittings may be used when made from malleable iron for additional fitting strength (see American Society of Mechanical Engineers (ASME) B16.3, Malleable Iron Threaded Fittings, Classes 150 and 300). Cast iron trim fittings, provided as part of a manufactured assembly, may be used when supported by appropriate engineering analysis."*

Appropriate engineering analysis is informed by the expected performance of the system during the applicable design basis event. This is particularly important if the system is expected to operate during and after the seismic event. The analysis should be conducted by personnel knowledgeable in determining seismic adequacy of fire protection piping and systems. Multiple potential failure mechanisms need to be evaluated, and testing may have to be performed to ensure adequate system capacity.

Recent testing conducted by Los Alamos National Laboratory (LANL) indicated that certain cast iron materials in FSSs performed better than expected. Testing may be beneficial in certain scenarios to show the adequacy of new or existing systems

when cast iron components are determined to be more suitable.

3. Implement inspection processes to identify potential corrosion and ensure continued operability of any cast iron components.

Recent interagency discussions with the Nuclear Regulatory Commission (NRC) presented the concern that cast iron piping and components may be subject to corrosion which degrades the strength properties and can alter the material dimensions. Having a process for inspecting and verifying adequacy of these components will contribute to ensuring continued operability. If specifying cast iron components in a new design or for an existing design, where cast iron is determined to be present, consideration should be given to the potential for degradation due to corrosion in the system's lifecycle. In this case, the frequency of required internal inspections of fire protection piping per NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, may need to be modified to ensure continued reliability of the system.

SUMMARY

Organizations should pay close attention to ensure specifications for FSSs properly flow down from the requirements documents to the installation of the systems in the field. DOE-STD-1066-2023 does not recommend using cast iron fittings in credited FSS but does provide an alternative.

The ongoing testing by LANL may provide more information on this topic in the future. EHSS will evaluate the outcomes of the current and future testing and consider those in future revisions of DOE-STD-1066-2023, as necessary.

Finally, cast iron components could have potential issues due to corrosion. Having processes in place to identify whether the corrosion effects of these components could impair their systems will help ensure continued reliability of the system.

REFERENCES

1. DOE-STD-1066-2023, *Fire Protection*
2. DNFSB Staff Report, *Pantex Plant 12-44 False Ceiling Replacement Review*
3. DOE/EH-0545, *Seismic Evaluation Procedure for Equipment in U.S. Department of Energy Facilities*
4. EPRI Report 1019199, *Experience-Based Seismic Verification Guidelines for Piping and Tubing*

This OE-3 document requires no follow-up report or written response.

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Questions regarding this OE-3 document can be directed to the Office of Nuclear Safety (EHSS-30) at NuclearSafety@hq.doe.gov.