

UNITED STATES
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OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
OFFICE OF FEDERAL AND STATE MATERIALS
AND ENVIRONMENTAL MANAGEMENT PROGRAMS
WASHINGTON, DC 20555-0001

June 3, 2013

NRC INFORMATION NOTICE 2013-09: COMPRESSED FLAMMABLE GAS CYLINDERS
AND ASSOCIATED HAZARDS

ADDRESSEES

All holders of an operating license or construction permit for a nuclear facility under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," including those that have permanently ceased operations and have spent fuel in storage in the spent fuel pool.

All holders of and applicants for a power reactor early site permit, combined license, standard design certification, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to alert addressees of the potential hazards associated with the placement of compressed flammable gas cylinders near safety-related and important to safety structures, systems and components (SSCs). The NRC expects that recipients of this IN will review the information for applicability to their facilities and consider actions, as appropriate. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Between 2011 and 2012, NRC inspectors identified six instances in which licensees failed to consider the potential impact on SSCs when locating compressed flammable gas cylinders in nuclear power plants. Inspectors identified and documented non-cited violations (NCVs) at Dresden Nuclear Power Station, Units 2 and 3; Duane Arnold Energy Center; Indian Point Nuclear Generating Unit 2; Kewaunee Power Station; Monticello Nuclear Generating Plant; and Prairie Island Nuclear Generating Plant.

Five of the plants listed installed or modified post-accident containment air monitoring systems by installing hydrogen and oxygen analyzers. The hydrogen and oxygen analyzers used compressed hydrogen and oxygen gas cylinders. During the modifications, the licensees did not perform safety analyses to evaluate the impact of a failure of the compressed flammable gas cylinders. A failure of a compressed flammable gas cylinder can result in a fire or an explosion that could potentially damage nearby SSCs. The NRC inspectors identified compressed flammable gas cylinders located near safety-related SSCs, such as residual heat removal system cables, motor control centers, and hydraulic control units. In several instances, inspectors also observed acetylene and methane gas cylinders located near safety-related

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SSCs. Acetylene is used in plants for welding and as a chemical reagent. The NRC inspectors documented NCVs of Criterion III, "Design Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 in each case. The five NCVs were not associated with the fire protection program requirements.

In the sixth example, NRC inspectors discovered a compressed flammable gas cylinder stored underneath cable trays containing safety-related cables in the primary auxiliary building (PAB). The cylinder was not in use, a valve cap was installed, and the cylinder was chained to a corridor wall to prevent accidental movement or tipping. The cylinder was labeled as flammable but was not labeled with the specific gas. The licensee previously used the gas as a calibration gas for a waste gas analyzer, but contrary to their control of combustibles procedure failed to remove the gas cylinder from the PAB after it was disconnected from the waste gas analyzer. Subsequently, the licensee removed the gas cylinder from the PAB and determined that it contained approximately 150 pounds per square inch gage (psig) of a mixture of 50 percent hydrogen and 50 percent nitrogen gases. The NRC inspectors documented an NCV for the licensee's failure to implement all provisions of the approved fire protection program.

In the examples discussed, the licensees entered the issues into their corrective action programs to evaluate the placement of the compressed flammable gas cylinders. Some of the licensees have completed fire hazards evaluations for the specific cylinder locations. Some licensees removed compressed flammable gas cylinders that were no longer in use and were stored in plant areas.

Additional information appears in the following NRC inspection reports:

"Dresden Nuclear Power Station, Units 2 and 3 Evaluation of Changes, Tests, or Experiments and Permanent Plant Modifications Baseline Inspection Report 05000237/2012008(DRS); 05000249/2012008(DRS)," dated April 23, 2012, in the NRC's Agencywide Documents Access and Management System (ADAMS) under Accession No. ML12114A356.

"Duane Arnold Energy Center Triennial Fire Protection Inspection Report 05000331/2012007," dated March 7, 2012, under ADAMS Accession Number No. ML12066A262.

"Indian Point Nuclear Generating Units 2 and 3 – NRC Inspection Report 05000247/2012009 and 05000286/2012008 and Notices of Violation," dated August 16, 2012, under ADAMS Accession No. ML12229A128.

"Kewaunee Power Station – Triennial Fire Protection Inspection Report 05000305/2011008," dated November 14, 2011, under ADAMS Accession No. ML11319A244.

"Monticello Nuclear Generating Plant Triennial Fire Protection Inspection Report 05000263/2011008," dated August 23, 2011, under Accession No. ML11235A897.

"Prairie Island Nuclear Generating Plant Evaluations of Changes, Tests, or Experiments and Permanent Plant Modifications Baseline Inspection Report 05000282/2011012(DRS); 05000306/2011012(DRS)," dated December 15, 2011, under ADAMS Accession No. ML11349A413.

BACKGROUND

The National Fire Protection Association (NFPA) Glossary of Terms 2012 Edition defines flammable gas as, "Any substance that exists in the gaseous state at normal atmospheric temperature and pressure and is capable of being ignited and burned when mixed with the proper proportions of air, oxygen, or other oxidizers." Common compressed flammable gases used at nuclear power plants include hydrogen, acetylene, and methane. Compressed flammable gases are hazardous because they can burn or explode when combined with oxygen and are within their flammability or explosive limits.

Compressed flammable gas cylinders present a fire and an explosion hazard. Hydrogen, acetylene, and methane gases are highly flammable and have the following flammability limits by volume at atmospheric pressure:

Combustible	Lower Flammability Limit	Upper Flammability Limit
Hydrogen	4%	75%
Acetylene	2.5%	100%
Methane	5%	15%

Reference: Table 2-7.1 of *The SFPE [Society of Fire Protection Engineers] Handbook of Fire Protection Engineering* (Fourth Edition - 2008).

A mixture of any of these gases within the flammability range will burn or potentially explode. Further, failure of nearby placed compressed oxygen cylinder(s) could intensify and increase the severity of a potential fire or explosion.

Appendix A to Branch Technical Position, Auxiliary and Power Conversion Systems Branch 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants, Docketed Prior to July 1, 1976," dated August 23, 1976 (ADAMS Accession No. ML070660458), Regulatory Position D.2(b) specifies that, "Use of compressed gases (especially flammable and fuel gases) inside buildings should be controlled."

Regulatory Guide 1.189, "Fire Protection for Nuclear Power Plants," Revision 2 (ADAMS Accession No. ML092580550), Section 2.1.4, states that, "when an SSC important to safety is near installations such as flammable liquid or gas storage, the licensee should evaluate the risk of exposure fires (originating in such installations) to the SSCs and take appropriate protective measures." The NFPA Code 55, "Compressed Gases and Cryogenic Fluids Code," 2013 Edition requires that compressed cylinders containing oxygen be separated from compressed cylinders containing flammable gases by a minimum of 20 feet as specified in Table 7.1.11.2, "Separation of Gas Cylinder, Containers, and Tanks by Hazard Class." In locations where compressed flammable gas cylinders are located within 20 feet of compressed oxygen cylinders, NFPA 55 requires the oxygen cylinders to be relocated.

The NRC has previously identified concerns associated with the use and storage of compressed flammable gas cylinders. The NRC documented concerns in IN 89-44, "Hydrogen Storage on the Roof of the Control Room," dated April 27, 1989 (ADAMS Accession No. ML031180843) with the location of hydrogen bottles near safety-related structures. The NRC also documented concerns in IN 91-37, "Compressed Gas Cylinder Missile Hazards," dated June 10, 1991 (ADAMS Accession No. ML070180064) involving compressed gas cylinders in which gas escaped from the cylinder and propelled the cylinder.

DISCUSSION

Regulations in 10 CFR 50.48, "Fire Protection," require that each operating nuclear power plant must have a fire protection plan that satisfies Criterion 3, "Fire Protection," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50. Criterion 3 requires that SSCs important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions.

Regulations in Criterion III to Appendix B of 10 CFR Part 50 require, in part, that design control measures shall provide for verifying or checking the adequacy of design, such as by the performance of design reviews, the use of alternate or simplified calculational methods, or the performance of a suitable testing program. Licensees are required to verify the adequacy of modifications such as the installation of compressed flammable gas systems and evaluate their potential effect on safety-related SSCs.

In the above identified examples, licensees did not fully consider the hazards that compressed flammable gas cylinders represent. Compressed flammable gas cylinders located near safety-related and important to safety SSCs have the potential to damage those components if the gas can escape from the cylinders and ignite or explode. Although the cylinders were properly restrained in the examples identified above, compressed gas cylinders pose a missile hazard if not properly restrained. The contents of a compressed gas cylinder can quickly escape due to the opening of or damage to a valve and cause the cylinder to become a projectile. This could lead to personnel injury or damage to SSCs.

The examples described in this IN illustrate potential licensee deficiencies. Addressees are encouraged to evaluate the placement of compressed flammable gas cylinders located within plant areas and the potential damage that would occur to nearby SSCs as result of the compressed flammable gas cylinders' failure (e.g., a fire, explosion, or missile hazard).

It is also important that fire protection elements of the approved fire protection program be maintained when plant modifications are made. Several of the examples discussed show that when licensees made modifications to their plant(s) to address one concern, they did not evaluate the potential effect of those modifications on other SSCs. Licensees need to ensure that the types of plant modifications discussed in this IN have no adverse effect on the fire protection design features and programs. Personnel in the fire protection organization may need to review modifications of SSCs to ensure that fire loadings are not increased beyond those accounted for in the fire hazards analysis, or if increased, suitable protection is provided and the fire hazards analysis is revised accordingly.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below or the appropriate NRC project manager.

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