



Testing of Nitrogen Atmospheres as a Glovebox Fire Suppression System

Nuclear Safety R&D Project

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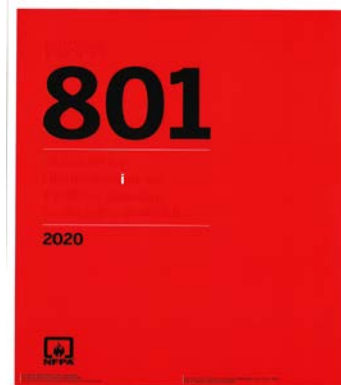
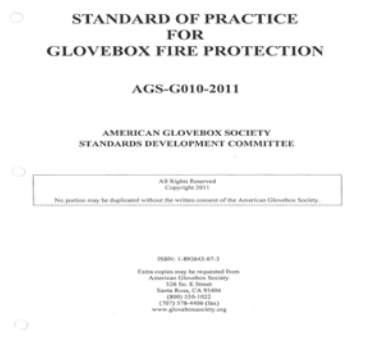
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Glovebox Fire Suppression Requirements

- **Both National Fire Protection Association and American Glovebox Society prohibit crediting an inert atmosphere as an automatic fire suppression system.**
 - NFPA 801 [2020 Edition] *Standard for Fire Protection for Facilities Handling Radioactive Materials*, paragraph 7.1.4.5.7 “Fixed inerting systems shall not be utilized in lieu of a fire suppression system.”
 - American Glovebox Society, (AGS)-G010-2011 *Standard of Practice for Glovebox Fire Protection*, Paragraph 7.3.1 “Glovebox inerting used as a fire-prevention measure shall not be credited as an automatic fire suppression system.”



Nitrogen Based Inert Atmospheres

- **Nitrogen is compatible with combustible metals and a Nitrogen based oxygen deficient atmosphere will prevent ignition of and can control/extinguish a fire involving ordinary combustibles or flammable/combustible liquids due to lack of oxygen to support combustion.**
- **No U.L. listed or Factory Mutual approved Nitrogen Fire Suppression System exists.**
 - CO₂ and Clean Agent systems are U.L. listed, but not compatible with Combustible Metals.
 - No approved National Consensus Standard for Nitrogen based fire suppression system.

Positive Test Results

- » **Demonstrate the Nitrogen Inert Atmosphere performance as fire suppression system tested at New Mexico Tech. in the summer of 2019.**
- » **Tests were observed by U.L. personnel, who provided a report of the tests.**
- » **The tests proved the Nitrogen based (Inert) fire system can:**
 - » Re establish and maintain inerting while not over pressurizing the glovebox
 - » Controlling the fire to extinguishment
 - » Integrates with the building fire alarm system to remotely notify emergency response personnel
 - » System discharge does not cause collateral damage
 - » Capable of operating using facility nitrogen or storage bottles with connected reserve
 - » Credit the inert atmosphere system for fire protection and prevention.

Test Reports

- » **A copy of the U.L. verification report, *Fire Suppression Systems for use in Glovebox Applications.....*, (File NC29671; Project 4789005583) will be available in a NNSA Technical Bulletin and can be obtained at following cloud address: <https://fireandpumpservice-my.sharepoint.com/:f:/p/frankb/EhTuwSRAXzXPohebq2NhP90BSOV0ZRNc8aoU6vpeITj7uw?e=FVS0sL>**

Hybrid Vortex Fire Suppression System and Test Glovebox



Glovebox Enclosure Schematic

Test Enclosure – Glovebox cont.

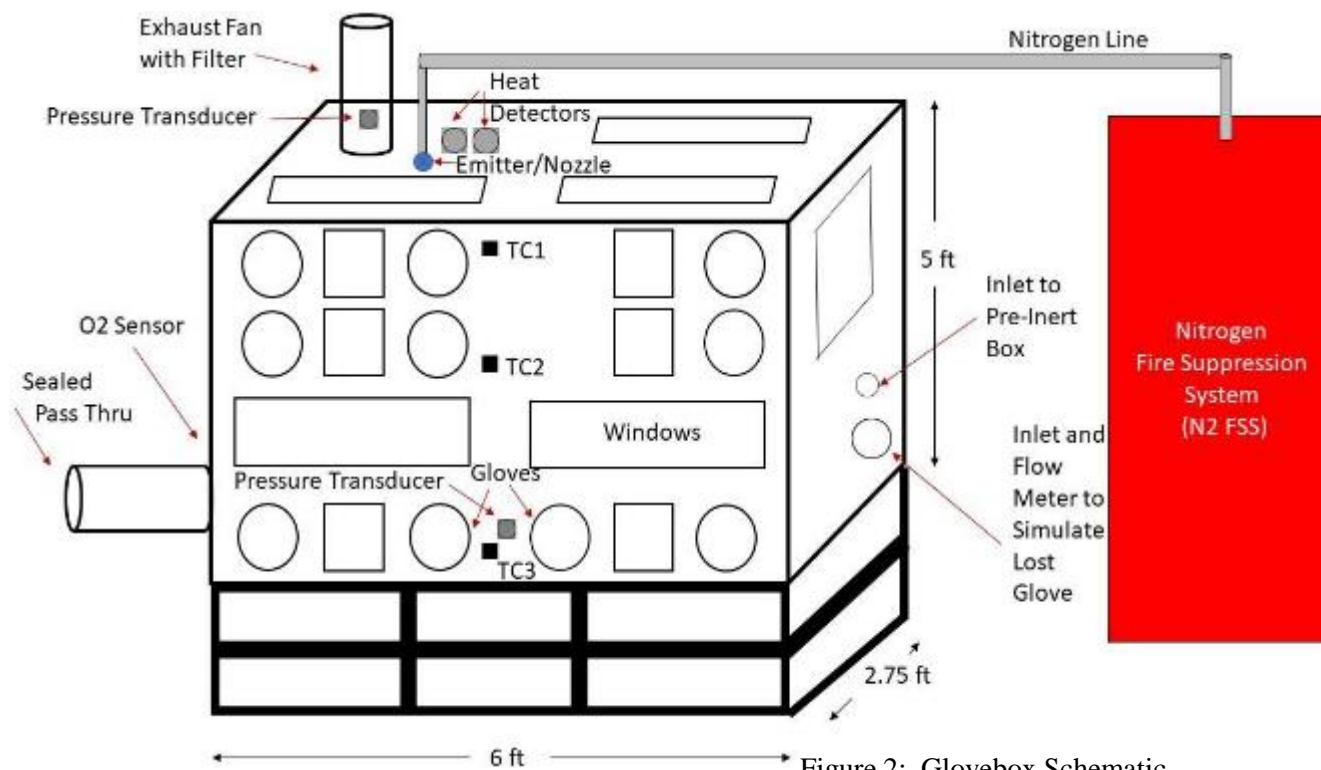


Figure 2: Glovebox Schematic

AMI Oxygen Monitor with Two Alarm Set Points



Pre-fire Fuels: Bags, Cheese Cloth, Acetone, Cardboard, Paper Towel, Heptane



The System Extinguished a Heptane and Alcohol Soaked Rag Fire



Test Results

» Simulation of Fire in the Glovebox

Test	Environmental Conditions		Test Configuration		Initial Parameters			Fuel Source						Testing Results					NOTES			
	Outside Room		Test Type	Agent	Glovebox			FSS	Heptane (mL)	Bags (no.)	Cloth (no.)	Acetone (mL)	Card Board (no.)	Paper Towel (no.)	Event	Time (min:sec)	Duration (min:sec)	Airflow (cfm)		Oxygen (%)	Pressure (in Aq)	
	Temperature (°F)	Humidity (% RH)			Temperature (°F)	Airflow (cfm)	Pressure (in Aq)															
8	84	16	Fire	Nitrogen		35.1	-0.50	40	100	6	6	60	N/A	N/A	Power Fans			35.1	20.8	-0.50	FIRES EXTINGUISHED Bags and Acetone Did Not Ignite	
															DAQ Started	00:00.0			20.8			
															Start Igniters	00:10.2	00:10.2		20.8			
															Ignition - Bags (Rt Back)	DNI	DNI		20.8			
															Ignition - Heptane + Bag (LfFront)	00:21.1	00:10.8		20.8			
															FSS Alarm / Heat Detectors	01:14.6	00:53.6		12.1			
															Computer Alarm / Heat Detector	01:23.7						
															FSS Manually Started	01:23.7	00:09.1					
															Extinguishment	01:42.2	00:18.5		12.1			
															FSS Manually Turned Off	02:58.0	01:15.7		4.1			
															End of Test	04:30.7	01:32.7		17.5			
10	86	16	Fire	Nitrogen	Cameras Only	32.6	-0.50	40	100	6	6	120	N/A	N/A	Power Fans			32.6	20.7	-0.50	FIRES EXTINGUISHED	
															DAQ Started	00:00.0			20.6			
															Start Igniters	00:29.5	00:29.5		20.5			
															Ignition - Bags (Rt Back)	00:41.0	00:11.5		20.5			
															Ignition - Heptane + Bag (LfFront)	00:55.8	00:14.8		20.5			
															FSS Alarm / Heat Detectors	01:51.6	00:55.8		16.4			
															Computer Alarm / Heat Detector							
															FSS Manually Started	01:51.6	00:00.0					
															Extinguishment	02:06.6	02:06.6		13.8			
															FSS Manually Turned Off	03:31.7	01:40.1		5.0			
															End of Test	04:30.3	02:23.7					

NNSA EFCOG Follow On Actions

- » **AGS-G010-2001 is being revised to allow an automatic fire protection system that creates or maintains the inert atmosphere to be credited as an automatic fire protection system, if approved by the AHJ.**
- » **Establish a DOE/NNSA ADHOC committee to develop nitrogen based fire protection system guidelines and standards that could be used to develop a NFPA standard, which would allow the nitrogen based fire protection system to be U.L. listed or F.M approved.**
- » **Modify DOE Standard 1066 to allow an engineered automatic fire protection system created inert atmosphere to be credited as fire protection until NFPA 801 is revised.**
- » **DOE/NNSA employees serving as NFPA 801 committee members seek to revise NFPA 801 to allow inert atmospheres to be credited as glovebox fire protection systems when the atmosphere is provided by a listed or AHJ approved automatic fire protection system.**

Revise NFPA 801

- » **DOE/NNSA/DNFSB employees serving as NFPA 801 committee members seek to revise NFPA 801 to allow inert atmospheres to be credited as glovebox fire protection systems when the atmosphere is provided by a listed or AHJ approved automatic fire protection system.**

Technical Committee on Fire Protection for Nuclear Facilities

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2020 System Development

- » **Currently researching, developing and conducting discharge testing of a nitrogen based fire suppression system that will include Magnesium Oxide sand as a suppression agent for pyrophoric metals as recommended by the DOE Handbook (DOE-HDBK-1081-94) *Primer on Spontaneous Heating and Pyrophorcity*, recommendation extinguishing agent:**
 - » (Page 36) “Magnesium oxide extinguishes the fire by providing a heat sink which cools the plutonium and by providing a barrier which limits the availability of oxygen.”
 - » (Page 38) “Uranium fires should be extinguished with the same techniques and precautions as plutonium fires....”