U. S. Chemical Safety and Hazard Investigation Board
RECOMMENDATIONS STATUS CHANGE SUMMARY

Report:	Airgas Facility Fatal Explosion
Recommendation Number(s):	2016-4-I-FL-R2 through R4
Date Issued:	March 17, 2017
Recipient:	Compressed Gas Association
New Status:	R2: Open – Acceptable Response or Alternate Response R3: Open – Acceptable Response or Alternate Response R4: Open – Acceptable Response or Alternate Response
Date of Status Change:	October 11, 2018

Recommendation(s) Text:

CSB Recommendation No. 2016-04-I-FL-R2
Safety Management System for Nitrous Oxide Manufacturing
Develop and implement a safety management system standard for nitrous oxide manufacturing, to manage known process safety hazards, including nitrous oxide decomposition, which includes appropriate elements based on chemical industry good practice guidance, such as CCPS Guidelines for Risk Based Process Safety, Essential Practices for Managing Chemical Reactivity Hazards, and Guidelines for Implementing Process Safety Management.

CSB Recommendation No. 2016-04-I-FL-R3
Ensure Effective Flame Arrestor Design
Modify Compressed Gas Association (CGA) standard CGA G-8.3, Safe Practices for Storage and Handling of Nitrous Oxide to require testing of safety devices, such as strainers used as flame arrestors, for applications where a safety device is used to quench a nitrous oxide decomposition reaction. To ensure that these safety devices meet the intended purpose, the user should test the safety device by simulating conditions of use. In addition, require users to document the required performance standard or test protocol followed.

CSB Recommendation No. 2016-04-I-FL-R4
Require Pump Run-Dry Safety Interlocks Apply ISA-84
Modify Compressed Gas Association (CGA) standard CGA G-8.3, Safe Practices for Storage and Handling of Nitrous Oxide to reference and require applying International Society of Automation (ISA) standard ISA-84, Functional Safety: Safety Instrumented Systems for the Process Industry Sector to safety interlocks such as the nitrous oxide pump "run-dry" shutdown.

Board Status Change Decision:

A. Rationale for Recommendation

On Sunday, August 28, 2016, at approximately 12:10 pm, a nitrous oxide trailer truck exploded at the Airgas manufacturing facility in Cantonment, Florida. The explosion killed the only Airgas employee present and heavily damaged the facility, halting nitrous oxide manufacturing

at Cantonment indefinitely. The CSB determined that the most probable immediate cause of the incident was that, during the initial loading of a trailer truck, a pump heated nitrous oxide above its safe operating limits. Exceeding these critical safety limits appears to have started a nitrous oxide decomposition reaction that propagated from the pump into the trailer truck, causing the explosion.

The CSB investigation found that Airgas lacked a safety management system to identify, evaluate, and control nitrous oxide process safety hazards, which led to the explosion. Although not required by Federal regulations, good practice recommends developing and implementing a robust safety management system to manage the hazards relating to manufacturing, transferring, and shipping nitrous oxide. The contributing causes of the explosion that killed the Airgas employee all stemmed from the company's lack of an effective overall process safety management system.

The CSB reviewed relevant industry standards by the Compressed Gas Association (CGA) and determined that a process safety management system for nitrous oxide manufacturing could provide guidance for better process safety in the nitrous oxide manufacturing industry. As a result, CSB issued several recommendations to the CGA—specifically, that the CGA: develop and implement a safety management system standard; require the testing of safety devices; reference the International Society of Automation (ISA) standard ISA-84, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*; and to apply that standard to safety interlocks, such as the nitrous oxide pump "run-dry" shutdown.

B. Response to the Recommendation

CGA stated that they intend to implement all three recommendations. Their Process Safety Committee is creating a new CGA publication to address several operations, including nitrous oxide, which is expected to be completed by mid-2019. Additionally, a joint working group should complete revisions to CGA publication G-8.3, *Safe Practices for Storage and Handling of Nitrous Oxide* in July 2018 for expected publication before the end of 2018. Revisions include the CSB recommendations on flame arrestors and pump run-dry safety interlocks and will reference and apply, among other things, the International Society of Automation (ISA) standard ISA-84, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*.

C. Board Analysis and Decision

Based upon the information above, the Board voted to designate the status of **CSB Recommendation Nos. 2016-4-I -FL-R2, 2016-4-I -FL-R3,** and **2016-4-I -FL-R4** as **"Open-Acceptable Response or Alternate Response."**