Assessing the Fire Performance of Calcium Hypochlorite and the Adequacy of Codes Governing its Storage in Retail Occupancies

National Association of State Fire Marshals
Catastrophic Fire Prevention Task Force
James A. Burns, Chairman

Introduction

The Catastrophic Fire Prevention Task Force of the National Association of State Fire Marshals (NASFM) was asked by the NASFM Board of Directors to conduct a data call and produce recommendations regarding the storage of oxidizers in retail occupancies and the fire performance of these oxidizers.[1] This concern for special review is prompted by recent large-loss fires in chemical production facilities, so-called "big box" retail stores and their regional distribution centers, which often store oxidizing pool chemicals in rack storage arrays that are readily available to the public.

The Task Force was asked not only to review laboratory data regarding the fire performance of these chemicals, but also to review the adequacy of the current codes governing the storage of these products and the management of fires involving these products. The Task Force received assistance from the NASFM Science Advisory Committee (SAC) in completing its assignment.

The specific oxidizer in question is known as calcium hypochlorite, a product that is widely used in swimming pools and for water treatment and sanitation purposes. Several recent incidents involving calcium hypochlorite have caused a great deal of damage to life and property, thus warranting a closer examination of the codes and practices governing this product.

In addition to wanting to ensure the safety of building occupants, users of oxidizers and firefighters who might respond to an incident involving calcium hypochlorite, the Task Force recognizes a homeland security concern: oxidizers such as calcium hypochlorite could be used in chemical weapons developed by terrorists to cause fires, explosions, casualties and the general disruption of the economy.

[1] For background on the NASFM Catastrophic Fire Prevention Task Force and other projects involving the Task Force, see http://www.firemarshals.org/issues/catastrophic/index.html.

Background

The Task Force and SAC requested all available information on the fire performance of calcium hypochlorite through a notice posted on the NASFM website.[2] Specific requests also were sent to Underwriters Laboratories (UL) and the Fire Protection Research Foundation, which have conducted joint research involving these products; calcium hypochlorite manufacturer Arch Chemical; BioLab, Inc., which markets calcium hypochlorite manufactured by Sterling Pulp Chemical; and the American Chemistry Council (ACC).[3] An affiliated business council of ACC called the Chlorine Chemistry Council deals with safety issues related to oxidizers, among other things. ACC also maintains a Chlorinated Pool Chemical industry panel. Of all those specifically asked to respond to the call for data, the ACC was the only one that did not respond in some way or another, though the Task Force was subsequently made aware of relevant resources available from ACC.

The National Fire Protection Association (NFPA) publishes more than 300 codes and standards for fire and life safety. The *NFPA 430, Code for the Storage of Liquid and Solid Oxidizers, 2000 Edition*, lists four classifications of oxidizers:

- A Class 1 oxidizer "does not moderately increase the burning rate of combustible materials with which it comes into contact."

- A Class 2 oxidizer "will cause a moderate increase in the burning rate of combustible materials with which it comes into contact."

- A Class 3 oxidizer "will cause a severe increase in the burning rate of combustible materials with which it comes into contact."

- A Class 4 oxidizer "can undergo an explosive reaction due to contamination or exposure to thermal or physical shock" and "will cause a severe increase in the burning rate of combustible materials with which it comes into contact."

A report of the Fire Protection Research Foundation observes, "This classification system is not based upon quantified data, is subject to interpretation, and therefore remains subjective."[4] The Task Force concurs with this concern, and calls for a greater degree of scientific certainty to support the classifications and criteria that govern the use and storage of these chemicals.

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[2] See the SAC's "Request for Data Pertaining to the Safety of the Pool Chemical Known as Calcium Hypochlorite" at http://www.firemarshals.org/issues/catastrophic/bulk_retail.html.

[3] The Task Force has recently learned that calcium hypochlorite manufacturers PPG and Sterling Pulp Chemical (now known as ERCO Worldwide) were not informed of the original request for data by the SAC. They will be sent a copy of this final report along with an invitation to submit information responsive to the subject matter.

[4] *National Oxidizing Pool Chemicals Storage Fire Test Project,* Fire Protection Research Foundation, August 1998, p. 1.

Calcium hypochlorite is classified either Class 2 or 3 oxidizer based upon the weight percent of calcium hypochlorite in a solution. A Class 2 oxidizer of calcium hypochlorite has 50 percent or less weight, and a Class 3 oxidizer of calcium hypochlorite has over 50 percent weight. This designation seems to have been an arbitrary division on the part of the NFPA 430 committee for purposes of storage and sale in retail occupancies. In review of the available information, there is no scientific data to establish the 50 percent division based on fire data performance differences between Class 2 and 3 oxidizers. The Task Force believes that the difference in the performance of oxidizers with a small weight difference in the calcium hypochlorite content would not significantly affect the outcome of a fire involving Class 2 or 3 oxidizers – for example, if 48 percent or 52 percent calcium hypochlorite by weight were used.

Transportation Issues

The US Department of Transportation (DOT), which regulates the transportation of hazardous cargo via highway, rail and air, has established 39 percent by weight of calcium hypochlorite in a solution for assignment of United Nations Numbers for hazardous material transport.[5] The US DOT "39 percent by weight" requirement for the transportation industry would imply a greater safety concern for calcium hypochlorite than is demonstrated by the NFPA 430 Code.

In fact, the hazardous transportation of calcium hypochlorite, while not a main focus of this Task Force assignment, cannot be ignored, particularly given the attractiveness of various modes of transportation as instruments of terrorism, coupled with the fact that calcium hypochlorite is readily available in stores with no restrictions on purchases. Authorities having responsibility for homeland security issues may be well advised to call for tighter standards governing the transport of calcium hypochlorite.

A significant increase in fires aboard cargo ships and a recognition that "calcium hypochlorite products have been improperly declared … in order to circumvent requirements imposed by concerned shipowners," prompted the International Maritime Organization[6] to issue Marine Safety Circular No 963 in June 2000, which determined the prevailing transport requirements for calcium hypochlorite to be inadequate and recommended amendments to the current requirements to impose much more strict handling and carriage of the product. These actions were preceded by similar recommendations from insurance carriers for ship owners as represented by the International Group of P&I Clubs.[7]

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[5] http://hazmat.dot.gov/erg2000/2201.htm (choose 2208, Calcium hypochlorite mixture, dry, with more than 10% but not more than 39% available Chlorine, Guide 140), http://hazmat.dot.gov/erg2000/g140.pdf.

[6] "Transport of Calcium Hypochlorite," MSC/Circ.963, 1 June 2000, International Maritime Organization, www.imo.org.

[7] "Calcium Hypochlorite (Hydrated) – UN 2880," 9 December 1998, www.lsso.com/circular/5262.htm; "The Carriage of Calcium Hypochlorite – UN Nos 1479, 1748, 2208, 2880," 30 November 1999, www.lsso.com/circular/5286.htm; "Recommendations on Carriage of Calcium Hypochlorite," 20 December 2000, www.lsso.com/circular/5299.htm; all issued by A Bilbrough & Co, Ltd.

While the NFPA 430 code is in revision cycle and the committee is reviewing proposals, the Task Force encourages the committee to consider that given the fire performance of calcium hypochlorite, a more conservative classification system should be considered. Given the fires involving calcium hypochlorite that have occurred in large retail occupancies, the current NFPA 430 Code does not appear to be adequate for maintaining a reasonable fire safe environment.

Fire Investigation Reports

The Task Force reviewed several investigation reports prepared by NFPA of fires involving calcium hypochlorite pool chemicals. A common theme of all of the reports is represented by the comment in one report that "These chemicals must be handled and stored properly, and they (oxidizers) pose a serious hazard when involved in fire."[8]

The Task Force also reviewed a fire investigation report provided by the Oregon State Fire Marshal's Office of a fire that resulted in fatalities when a passenger vehicle carrying a family of five erupted into flames as it was being driven along a highway. The cause was listed as a half-full box of pool chemicals (determined to be calcium hypochlorite) and a petroleum-based engine cleaner "in close proximity [which] combined to ignite and cause a rapidly spreading fire."[9] The rapid fire development did not allow the passengers time for escape, and two children in the back seat burned to death, while the remaining passengers were hospitalized in serious condition. This investigation report clearly stated, "The fire was determined to be accidental … caused by an exothermic chemical reaction of cargo being transported by the owners of the vehicle. Gunk brand Engine Brite, Heavy Duty Engine Degreaser by Radiator Specialty Company and Shock-It brand, dry condensed pool chlorine (i.e., calcium hypochlorite) by Arch Chemical were the two chemicals identified as causing the exothermic reaction."[10] Fire investigators who combined the two chemicals in a field test confirmed the reaction and stated that the fire burned very intensely for about 20 seconds, followed by visible flames for 3 minutes, with visible smoldering for about 11 minutes thereafter.[11]

Fire/Explosion Performance and Related Hazards

Fire research submitted to the data call provides further understanding of the fire performance of calcium hypochlorite.

- Various abstracts describing research on the thermal decomposition of calcium hypochlorite note the explosive nature of the material and propensity to generate high temperatures and ignite nearby combustibles.

[8] National Fire Protection Association report, Warehouse Fire, Phoenix, AZ, August 2, 2000, p. 34.
[9] State of Oregon, Office of State Fire Marshal, Fire and Life Safety Supplemental Investigation Report, June 26, 2002, Passenger Vehicle Fire, Highway 18 MP 38.7, Sheridan, OR, page 2.
[10] Ibid., page 6.
[11] Ibid., page 6.

- The Fire Protection Research Foundation conducted sprinklered fire tests to determine if calcium hypochlorite affected the burning rate of containers that are considered "ordinary commodities" in order to better categorize these commodities per the classification system in NFPA 430 and "to develop documentation for storage parameters and automatic sprinkler protection design criteria for oxidizing pool chemicals that are stored in bulk merchandizing retail buildings."[12]

  Key findings of the report are as follows:

  A. Current sprinkler protection at the ceiling height in retail occupancies will not necessarily control a fire involving calcium hypochlorite. Current density requirements for sprinkler protection systems do not provide the needed water flow for suppression of the fire. Therefore, a larger quantity of water supplemented by the fire department with large hose streams is necessary. The sprinkler system and fire department capability can be overcome when large quantities of combustible materials are present in large retail occupancies.

  B. In-rack sprinkler protection with additional barriers installed around bins or shelves for storage of calcium hypochlorite in 70-lb. containers can contain a fire in the storage bin. Without the proper barriers and in-rack sprinkler protection, containment of the fire may not be possible.

  C. Fires occurring in large retail occupancies involved calcium hypochlorite either as the ignition source or as product that would have accelerated the fire. The absence of in-rack sprinkler protection for calcium hypochlorite and other fire safety barriers may have dramatically contributed to the fire scenario.

  D. The burning calcium hypochlorite in the tests conducted without sprinkler protection resulted in extremely high temperatures and rates of heat release. According to the report, "The combustion/decomposition process accelerated so quickly that the 10mW large-scale calorimeter was incapable of capturing and measuring the actual heat release rate due to spill-over."[13] The fire test clearly demonstrates the hazard if any quantity of calcium hypochlorite is placed on shelves in a mass retail establishment without sprinkler protection.

- Other research testing on calcium hypochlorite came to much the same conclusions as the Fire Protection Research Foundation. Fire testing was conducted in January 2000 by Southwest Research Institute's Department of Fire Technology in San Antonio for BioLab, Inc., on behalf of the Fire Safe Pool Chemicals Technical Advisory Committee (TAC). Calcium hypochlorite's reactivity to fire was tested under a standard fire protection strategy in a simulated retail environment, with the product stored on a standard pallet rack. The amount of calcium hypochlorite tested "represented 35% (804 lb) of the amount currently allowed in NFPA 430, in retail

[12] *National Oxidizing Pool Chemicals Storage Fire Test Project,* Fire Protection Research Foundation, August 1998, p. 3.
[13] Ibid., p. 20.

occupancies with sprinklers."[14] The sprinkler system was designed for Ordinary Hazard-Group 2 protection as defined by NFPA 13 Section 1-4.7.2.2 ("Occupancies or portions of other occupancies where quantity and combustibility of contents is moderate to high, stockpiles do not exceed twelve feet, and fires with moderate to high rates of heat release are expected").[15]

This study clearly shows that the current maximum allowable quantities in NFPA 430 exceed the ability of sprinklers to control the fire involving calcium hypochlorite (class 3 oxidizer).

Key findings of the report are as follows:

A. Within 25 seconds of ignition of the calcium hypochlorite, 12 of 12 sprinklers activated.

B. Within 1:30 minutes of ignition of the calcium hypochlorite, flames completely engulfed the commodity pallet area of the racks and extended past the commodity array. According to one fire prevention officer who witnessed the testing, "It was clear to all who watched that the standard safety equipment could do nothing to diminish the enormous fire that broke out."[16]

C. At 1:36 minutes of ignition of the calcium hypochlorite, over-pressurization of the test room caused a blowout of a 24 x 14 foot section of the wall of the test chamber. A minute later, at 2:30, all fuel had been consumed.

D. Test results indicated that the fire growth was not controlled by the suppression system, and the intense heat caused the sprinkler water to evaporate rapidly. The report concluded, "The calcium hypochlorite test clearly demonstrated that while quantities of product and the protection scheme chosen fell well within the regulations, the fire was not acceptable in terms of the safety risk."[17]

E. The report further noted that "scope of work indicates that different products, designed for similar consumer uses, can behave differently under fire conditions. Their behavior is justification for a reconsideration of protection strategies. This concept can be further exercised through additional large-scale tests that can help

[14] "A Comparative Evaluation of the Performance of a Water-Based Automatic Sprinkler System in the Protection of Pool Chemicals," prepared for BioLab, Inc., by Southwest Research Institute's Department of Fire Technology, SwRI Project No. 01.03453.01.001, May 2000, p. 11.
[15] *NFPA 13, Standard for the Installation of Sprinkler Systems* (latest edition 2002), National Fire Protection Association.
[16] "Calcium Hypochlorite: Does it justify concern as a potentially dangerous threat?" *Emergency Services SA*, Vol. 21, No. 3, May/June 2000, ISSN 1021-4763, pp. 14-15.
[17] "A Comparative Evaluation of the Performance of a Water-Based Automatic Sprinkler System in the Protection of Pool Chemicals," prepared for BioLab, Inc., by Southwest Research Institute's Department of Fire Technology, SwRI Project No. 01.03453.01.001, May 2000, p. 13.

to identify products within a product class where additional protection is required."[18]

Firefighter Safety Issues

Once started, fires involving calcium hypochlorite propagate so quickly that it is unlikely that firefighters would arrive in time to attack and extinguish the fire. Therefore, sprinkler systems must be designed to control a fire involving calcium hypochlorite. In addition, maximum allowable quantities of calcium hypochlorite should be reduced.

According to the Fire Protection Research Foundation report, "Firefighters should be particularly aware of a phenomenon witnessed during a couple of the sprinkler tests where the sprinklers provided a rapid knockdown of the visible fire in the compartment. In such a case there would be strong temptation to shut down the sprinklers and assume the fire was out. **However, commodity containers were observed to suddenly flare up strongly, even after several minutes of no visible fire being present, and with the sprinklers still operating** [emphasis in original]**.** As a precaution, fire fighters should have charge hand lines in place near the compartment **before** shutting down the sprinklers [emphasis in original]. Extreme caution should be exercised in overhauling commodity containers which have been exposed to fire, due to the possibility of re-ignition, and also the liberation of noxious gases." [19]

Recommendations

Calcium hypochlorite is an extremely dangerous product that either through criminal acts, misuse or unfortunate combinations of circumstances can endanger both emergency responders and the general public with its potential for creating violent, intense fires and explosions. Calcium hypochlorite severely accelerates combustion, which is consistent with the classification per NFPA 430 as a Class 3 oxidizer. Incidents involving the product have resulted in severe casualties and deaths – even in factories where one would expect highly trained personnel, and even in small quantities. Of particular concern is the accessibility of the product in "big box" bulk retail outlets, where proximity to other fuels and large numbers of people combine with inadequate sprinkler protection to create a series of disasters waiting to happen.

The NASFM Catastrophic Fire Prevention Task Force, having reviewed available information on the fire performance of calcium hypochlorite, makes the following recommendations to retailers, enforcers, standards developers and code officials:

- Current NFPA 430 code requirements are not adequate to meet current fire safety requirements for protection of the public, the retail occupancy or emergency responders. This standard does not ensure safety. Science-based requirements should be adopted promptly.

[18] Ibid., p. 21.
[19] *National Oxidizing Pool Chemicals Storage Fire Test Project,* Fire Protection Research Foundation, August 1998, p. 19.

- The "maximum allowable quantities" of calcium hypochlorite in retail establishments as per NFPA 430 are not substantiated scientifically. Retailers and NFPA should reduce the "maximum allowable quantities" of calcium hypochlorite to less than 400 lb until scientific testing can be performed to substantiate higher limits.

- Sprinkler protection requirements for the storage of calcium hypochlorite in retail establishments must be determined by the NFPA Sprinkler Committee, NFPA 13.

- Fire Marshals must enforce and retailers must comply with the reduced maximum allowable quantities described within these recommendations in retail occupancies.

- Calcium hypochlorite should not be merchandised in non-sprinklered occupancies.

- Labels to identify calcium hypochlorite as a potential high fire hazard risk to the public must be improved and displayed prominently in the vicinity of the merchandising display.

- Stricter regulations regarding the transportation of calcium hypochlorite should be developed, particularly in light of homeland security concerns.

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Standards and regulations governing the fire protection, storage, labeling and transportation of calcium hypochlorite must be strengthened to avoid further loss of life and property. However, because regulatory and standards development processes move slowly, the NASFM Catastrophic Fire Prevention Task Force strongly encourages retailers to adopt the recommendations above voluntarily rather than waiting for regulations to require them.