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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation November 6, 2000

Warehouse Fire Claims the Life of a Battalion Chief - Missouri

SUMMARY

On December 18, 1999, a 47-year-old male Battalion Chief (the victim) was fatally injured during a paper warehouse fire. Fire fighters were dispatched to the fire and upon arrival they immediately ordered all employees to evacuate the approximately 300,000-square-foot warehouse. The fire was located in the paper-bale section and was causing the structure to fill with a haze of white smoke. The Incident Commander (IC) assumed overall command and ordered an interior fire attack. He also ordered the Battalion Chief (the victim) from Car 106 to take command of interior operations. The fire fighters battled the fire for approximately 52 minutes before the IC and the victim decided conditions were deteriorating and they should go to a defensive attack. The IC ordered all fire fighters to evacuate the structure, however, several fire fighters' radios malfunctioned and they did not receive the evacuation order. Some of the fire fighters with the malfunctioning radios eventually ran out of air, became disoriented, and needed assistance to exit. The victim also became disoriented and did not exit. After learning that all the fire fighters except for the victim had exited, the IC ordered the two initial Rapid Intervention Teams (RITs) (RIT #1 and #2) to enter and search for the victim. Both teams entered but eventually ran low on air and were forced to exit without the victim. Additional RITs were formed and found the victim approximately 1½ hours after the initial dispatch. He was transported to a nearby hospital where he was pronounced dead. NIOSH investigators concluded that to minimize similar occurrences, fire departments should

- ***ensure that the department's Standard Operating Procedures (SOPs) are followed and refresher training is provided***
- ***ensure that all fire fighters performing fire fighting operations are accounted for***
- ***ensure that proper ventilation equipment is available and ventilation takes place when fire fighters are operating inside smoke-filled structures***
- ***ensure that one of the first-arriving engines be assigned to pump water into the building's fire department sprinkler connection to reinforce the automatic sprinkler system***

Incident Site.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

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- ***ensure that when entering or exiting a smoke-filled structure, fire fighters follow a hoseline, rope, or some other type of guide***
- ***ensure that fire fighters are equipped with a radio that does not bleedover, cause interference, or lose communication under field conditions***
- ***ensure that when fire fighters suspect that they have been exposed to carbon monoxide that they notify their officer or the IC and receive the proper medical care***
- ***ensure that a rehabilitation area is designated when needed***
- ***ensure that the assigned Rapid Intervention Team(s) (RIT) complete search and rescue operations and are properly trained and equipped***
- ***ensure consistent use of Personal Alert Safety System (PASS) devices at all incidents and consider providing fire fighters with a PASS integrated into their Self-Contained Breathing Apparatus***
- ***develop and implement a SCBA preventative maintenance program to ensure that all SCBAs are adequately maintained.***

Additionally, building owners, supervisory staff, or employees should

- ***ensure that fires are reported to the fire department immediately.***

INTRODUCTION

On December 18, 1999, numerous fire fighters were involved in battling a paper warehouse fire. As conditions deteriorated, the Incident Commander (IC) and the interior command Battalion Chief (the victim) decided to evacuate fire fighters from the structure and change operations to a defensive attack. The victim became disoriented and did not exit. Several RITs entered the structure to search for the victim, and at approximately 1945 hours the victim was found unconscious. The victim was later pronounced dead at a nearby hospital.

The National Institute for Occupational Safety and Health (NIOSH) was notified of this incident on December 20, 1999, by the U.S. Fire Administration and the International Association of Fire Fighters (IAFF). On December 26-28, 1999, an investigation of this incident was conducted by four Safety and Occupational Health Specialists from (NIOSH). Meetings were conducted with the Fire Marshal, the Chief, Deputy Chiefs, representatives of the IAFF, and the department's Safety Officer. Interviews were conducted with the Fire Chief, Deputy Chiefs, and fire fighters involved in the incident. NIOSH investigators reviewed copies of the department's Standard Operating Procedures, dispatch tapes, transcriptions of the dispatch tapes, the autopsy report, the incident accountability sheet, drawings of the structure, photographs of the incident scene, the victim's training records, and a video of the department's incident critique. A site visit was conducted and photographs of the structure were taken.

The fire department involved in this incident serves a population of 448,000 in a geographical area of 316 square miles. The department is comprised of 779 career fire fighters. The department requires all new fire fighters to complete the following training: Fire Fighter Level I and II, driver operator, and emergency medical training. Refresher training is provided on a monthly basis and covers all areas of the standard training. The victim's training records were reviewed and appeared to be sufficient and complete. The victim had 26 years of experience as a fire fighter.

The structure was a metal-pole building constructed on a concrete slab foundation. The interior roof system contained metal roof trusses, and the exterior was constructed of metal, rubber, and stone particulate. The single-story structure was originally used as a grocery warehouse; currently the structure houses a paper products manufacturer. It measured approximately 25 feet in height, 500 feet in width, and 600 feet in length.

The origin of the fire was determined to be in the paper bale section of the building (see Diagram 1). This section of the building had no windows. There were six exterior vents in this section, all located at the ceiling level (see Photo 1). There were 13 dock doors located in this section, and one standard door was located on the south side. The ventilation system was not in operation when the fire occurred. The structure was equipped with a sprinkler system.

Additional companies responded to this incident; however, only actions of those directly involved in this incident are included in this report.

INVESTIGATION

On December 18, 1999, at 1813 hours, Central Dispatch received a call of a fire in a paper warehouse. *Note: The employees of the warehouse attempted to combat the fire with extinguishers for approximately 15 minutes before notifying the fire department.* The following companies were dispatched:

1st Alarm 1814 Hours

- Car 105 (Battalion Chief (Incident Commander (IC)), a District Safety Officer (DSO))
- Car 106 (Battalion Chief (the victim) and a DSO)
- Pumper 18 (Captain, Fire Apparatus Operator (FAO), and a fire fighter)
- Pumper 24 (Captain, FAO, and one fire fighter)
- Pumper 35 (Captain, FAO, and one fire fighter)
- Rescue 9 (Captain, FAO, and one fire fighter)
- Rescue 11 (Captain, FAO, and two fire fighters)
- Truck 2 (Captain, FAO, and two fire fighters)
- Truck 5 (Captain, FAO, and two fire fighters)
- Air 1 (air supply) (FAO)

2nd Alarm 1825 Hours

- Car 104 (Battalion Chief)
- Pumper 17 (Captain, FAO, and one fire fighter)
- Pumper 32 (Captain, FAO, and one fire fighter)
- Rescue 31 (Captain, FAO, and two fire fighters)
- Truck 11 (Captain, 2 FAOs, and one fire fighter)
- Truck 13 (Captain, FAO, and two fire fighters)
- Hazmat 71 (Captain, two FAOs, and two fire fighters) (RIT #1)
- Incident Safety Officer

3rd Alarm 1842 Hours

- Pumper 23 (Captain, FAO, and one fire fighter)
- Pumper 39 (Captain, FAO, and one fire fighter)
- Truck 10 (Captain, two FAOs, and one fire fighter)
- Car 102 (Battalion Chief, and a Captain)
- Heavy Rescue 1 (Captain, FAO, and two fire fighters) (RIT #2)
- Pumper 47 (Captain, FAO, and one fire fighter)

Staffing 2nd 1853 Hours

- Car 100 (Chief)
- Car 101 (Deputy Chief)
- Car 200 (Deputy Chief)
- Car 201 (Deputy Chief)
- Car 213 (Division Head)
- Car 214 (Division Head)
- Car 206 (Division Head)
- Car 208 (Division Head)
- Car 203 (Fire Marshal)
- Car 204 (Assistant Fire Marshal)

4th Alarm 1853 Hours

- Pumper 8 (Captain, FAO, and one fire fighter)
- Pumper 29 (Captain, FAO, and one fire fighter)
- Pumper 43 (Captain, FAO, and one fire fighter)

- Rescue 12 (Captain, FAO, and two fire fighters)
- Truck 6 (Captain, FAO, and two fire fighters)
- Car 107 (Battalion Chief, and a Captain (DSO))

Pumper 18 and 24 arrived on the scene at 1820 hours and reported light smoke showing from the rear. At 1822 hours, all companies responding to the first alarm were on the scene. The Battalion Chief in Car 105 assumed command (IC) and requested a second alarm due to the size of the structure (approximately 300,000 square feet). The IC ordered the Battalion Chief (the victim) from Car 106 to enter the structure and assume interior command. The IC positioned his car in the southeast corner where the fire attack would take place and reported a size-up. The size-up indicated a large warehouse, approximately 200 feet by 300 feet, with light smoke at the south end (see Diagram 2 Apparatus Layout). The IC's District Safety Officer (DSO) entered the warehouse and reported that employees were still inside. The IC ordered an employee evacuation and ordered the Battalion Chief from Car 104 to meet with the plant supervisor to make sure all employees were accounted for when he arrived on the scene. At 1825 hours, the IC reported to dispatch that they had paper burning. At approximately the same time, Car 104 arrived on the scene and informed the IC that all the employees were accounted for. The victim (interior command) reported to the IC that paper bales were on fire and that he thought that they could suppress the fires with several handlines (see Photo 2).

At 1825 hours, Pumper 18 advanced a 1 3/4-inch handline through the south end door. A second 1 3/4-inch line was advanced by Pumper 35 through the same door. Pumper 24 advanced a third line through one of the dock doors (see Diagram 2 Apparatus Layout). Rescue 11 and Pumper 17 (only part of their crew) entered with Pumper 18 and Pumper 24 to assist them with their lines. The second-alarm companies arrived on the scene and the IC ordered all fire fighters on the fireground to switch their radios from channel 5A to the talk-around channel. *Note: En route to the scene, the victim had advised the IC that they might have radio problems, due to past experiences with their radios in this type of structure. The fire department is equipped with an 800 mhz trunked system.* Recognizing that communication problems might occur, operations were assigned to the talk-around channel.

At 1826 hours, Truck 11 was dispatched to respond to the scene. Rescue 31, a second-alarm company, was assigned as the Rapid Intervention Team (RIT), but as they approached the scene the IC ordered them to advance a 2½-inch master stream (large-size attack line) to the interior. The IC ordered Hazmat 71 to take over as the RIT (RIT #1). The remaining fire fighters from Pumper 17, who did not enter with Pumper 18 and Pumper 24, assisted Rescue 31 with the 2½-inch line. Members from Truck 5 and Truck 2 also entered the structure to assist with the lines as other members from Truck 5 raised the aerial ladder to the roof to check conditions. Truck 5's radio would not switch to the talk-around channel, requiring the IC to monitor two channels at all times. Truck 11 arrived and assisted the crews advancing the lines to the interior and also strung lights to the interior to improve visibility. Fire fighters in the interior reported varying smoke conditions, ranging from heavy, white smoke banking down from the ceiling to the mid-part of the structure on the south side, to light haze at other locations inside the structure. Other fire fighters in the interior reported that approximately 20-foot flames were extending from the paper bales to the ceiling on the opposite side of the initial fire attack (see Diagram 1). The victim and the DSO from Car 105 radioed the IC and told him that the fire was in the bales and not in the structure and that the visibility was fair. *Note: The electrical power was still on in the warehouse.* Fire fighters stated that at various times throughout the attack, they were able to remove their

SCBA face pieces, because the smoke was shifting around. The victim was seen, without his face piece donned, by several fire fighters during the attack.

As the fire attack progressed, fire fighters stated that as they hit the fire it would move in and out of bales, from one area to another. Some of the fire fighters then moved from the south side of the paper bales to the east side of the bales to get a better angle on the fire attack. The victim, who was assessing the fire from the south end of the paper bales, went around to the north end to evaluate the conditions. The DSO from Car 105 told the victim that he would remain on the south side and monitor conditions. The victim radioed the IC and requested a forklift to move some of the plant equipment to get a better position on the fire. The victim positioned himself approximately 15 feet away from the paper bales, near a chain-link fence (see Diagram 1 and Photo 3). At 1841 hours, dispatch notified the IC that the 15-minute clock had just expired. *Note: Dispatch starts a running clock for the IC when the crews first enter a structure. The clock provides the IC with information on how long crews have been in a structure.* Concerned about the time the fire fighters had been inside, the IC radioed the victim to report on the interior conditions. The victim stated that conditions were about the same and there was not much heat, just smoke. Based on the time-of-fire activity, the IC requested a third alarm at 1842 hours. Heavy Rescue 1 responded as a part of the third alarm and was ordered by the IC as the second RIT (RIT #2) when they arrived on the scene. The IC also requested that an additional Battalion Chief (Car 102) respond and replace the victim in the interior when he arrived. At 1853 hours, the IC requested a staffing second, which required all staff officers to report to the scene. Central Dispatch had also dispatched Pumper 8, Pumper 29, Pumper 43, Rescue 12, Truck 6, and Car 107 as a fourth alarm.

At this point, members from Truck 5, Truck 2, and Truck 10 were on the roof attempting to ventilate. The truck companies reported that the roof had several layers of materials and that they had difficulty getting through it with the saw blades they were using. The victim requested a 2½-inch street pipe (heavy stream appliance used to connect two hoselines together) be brought into the structure on the north end where the paper bales were located. Rescue 31 took their 2 1/2-inch line and connected it to the street pipe which was located near the front of the paper bales (see Diagram 1). Pumper 23, with the assistance of Rescue 9, stretched a second 2½-inch line through a dock door. The fire fighters met up with the Captain from Pumper 17 and connected their 2 1/2-inch line into the street pipe (two 2 1/2-inch lines were now connected to the street pipe). Shortly after the street pipe was opened, heavy smoke banked down, causing poor visibility. A fire fighter from Rescue 9 stated that he saw the victim don his face piece at this time. The IC then requested the power to the warehouse be shut off in fear of a fire fighter possibly being electrocuted. The power was shut off and the lights went out, which decreased visibility. The Battalion Chief from Car 102, who was to replace the victim, arrived on the scene and requested the victim's position. The victim told Car 102 to follow Pumper 23's line, as he was close by it. At 1856 hours, dispatch notified the IC that the second 15-minute clock had expired and they would be starting a third. The IC felt they were not making much progress against the fire with the hoselines, and requested dispatch to order foam to the scene. Pumper 39 arrived on the scene and was directed to hook into the sprinkler-system standpipe connection. Pumper 39's crew stated that water was flowing into the system, but crews in the interior could not recall if the sprinklers were activated.

Fire fighters who were battling the fire had exited and reentered several times to refill their air bottles. Since visibility was poor, the victim radioed the IC

and requested lights be placed at the dock doors so fire fighters could see their way out. He also requested a second RIT be placed in staging (not knowing that Heavy Rescue 1 had already been assigned as the second RIT). The IC informed him they were already in place. Car 104, who had entered to check conditions, reported to the IC that smoke conditions inside were untenable, and all fire fighters should be evacuated from the building. The IC radioed the victim and relayed the message from Car 104, requesting his opinion. The victim reported that conditions had worsened and agreed they should evacuate the structure. Fire fighters stated that at this point there was still little heat, but poor visibility at the floor level. The IC was also concerned the fire would compromise the integrity of the roof, since he had fire fighters on the roof. At 1912 hours, the IC requested that dispatch sound an emergency evacuation signal. The dispatch transmissions could only reach the tactical channel (channel 5A) so the IC keyed the talk-around channel mike and placed it in front of the channel 5A speaker to transmit the emergency evacuation signal over the talk-around channel. The IC ordered all companies to return to their apparatus and conduct roll-call. He also ordered all Fire Apparatus Operators (FAOs) to blow their air horns as another evacuation signal to fire fighters inside.

After making an L-shaped cut in the roof, fire fighters on the roof reported that they heard the emergency evacuation signal and immediately exited the roof. *Note: Roof ventilation had not been completed when they exited the roof.* Several fire fighters in the interior reported that they did not receive the emergency evacuation signal over their radio or hear the air horns. Several radios became wet during the operation and were not functioning properly, while other radios apparently did not receive the signal. As the emergency evacuation took place, fire fighters started to exit because their low-air alarms sounded. A fire fighter from Rescue 9 (still near the street pipe), who did not receive the emergency evacuation call, recalled seeing the Captain and two fire fighters from Rescue 31 attempting to exit. The Captain and both fire fighters were out of air and had pulled off their face pieces. The fire fighter grabbed the Captain and two fire fighters and started buddy-breathing with them. The fire fighter from Rescue 9 found a 2½-inch line and started to lead them out, stopping every 10 feet to buddy breathe. Following the line, they ran into an entanglement of hoselines and became disoriented. He heard the Captain of Rescue 31 radio the IC telling him that they were out of air and needed someone to get them out. The IC ordered the FAOs to shine their spotlights into the dock doors to assist the disoriented fire fighters. The disoriented fire fighters became separated and the fire fighter from Rescue 9 ran out of air. Another fire fighter from Rescue 9, who was exiting with them, ran into the crew from Rescue 31. He noticed the Captain moving slowly so he grabbed him and started moving toward what he thought was an exit. He too ran out of air and pulled off his face piece. All five disoriented fire fighters eventually made it out through a dock door near the south end. Both fire fighters from Rescue 9 stated that they felt very tired and confused. *Note: Several fire fighters in the interior either were not equipped with or did not turn on their Personal Alert Safety System (PASS) device.*

The IC had a report that Pumper 24's radio was transmitting an emergency signal, but shortly after Pumper 24 reported to the IC that they were all accounted for. Then, over the talk-around channel, the IC received a call for help from someone still inside. The IC asked who needed help and the victim responded by saying "106." The victim was unable to tell the IC his location inside the structure. The IC told him they were sending in the initial RITs (Hazmat 71 [RIT #1] and Heavy Rescue 1 [RIT #2]) to find him. Unable to locate his Chief, the victim's DSO

reentered the structure to search for him. The DSO stated he did not have a PASS device on when he entered (his PASS device was broken and he did not have a replacement). The DSO made two attempts to enter and locate the victim, then briefed the RITs preparing to enter. The IC ordered that all radio traffic be at a minimum and for all companies to switch back to channel 5A. Car 100 (Chief) arrived at 1921 hours and was given an update of the situation, including concerns about the structure. Car 100 and the IC concurred that the search activities would remain the priority and ordered both RITs to enter the warehouse and search for the victim.

At approximately 1921 hours, the Heavy Rescue 1 (RIT #2) entered the structure with a rope through one of the dock doors on the south end (see Photo 4). After donning their equipment, Hazmat 71 (RIT #1) entered with a rope, behind Heavy Rescue 1. Heavy Rescue 1 went toward the area where the victim was last seen, and searched until three of the fire fighters' low-air alarms sounded and they exited the structure. The Captain and his FAO continued the search until their low-air alarms sounded and they exited the building. The Hazmat 71 crew searched an area in the front of the structure, until their low-air alarms sounded and they exited the structure. *Note: Hazmat 71 was equipped with one-hour air bottles.* At least seventeen additional fire fighters reported that they entered the structure to search for the victim at various times during this interval.

Seven of the additional seventeen fire fighters formed two additional RITs (RIT #3 and #4); however, several other fire fighters reportedly entered the structure alone and without the IC's direction. Both RITs (#3 and #4) entered the warehouse with additional ropes to search for the victim. Five additional officers and the DSO from Car 105 were assigned to assist the IC with accountability by staying at the doors the RITs were using, since the RITs and fire fighters who completed the search and rescue attempts entered and exited at different locations (see Diagram 2).

Throughout the search, the victim radioed that he thought he was in the same location where he was when the smoke banked down (near the chain-link fence). At approximately 1928 hours, he said that he was out of air and was breathing off the floor and asked if all other personnel were accounted for. The IC noticed that his voice was labored and garbled. The IC asked the victim if he could manually activate his PASS device, but received no response. No further communications with the victim were received. At 1932 hours, dispatch advised the IC that the fourth 15-minute clock had expired and they would be starting a fifth. The IC then ordered dispatch to notify a mutual-aid department to respond with a thermal imaging camera.

At 1937 hours, the IC requested the electrical power to the building be turned on to restore lighting. The power was restored and Heavy Rescue 1 (RIT #2) reported to the IC that they were changing their air bottles and would be ready to go back inside. The IC told RIT #2 to brief one of the other RITs (RIT #3 or #4) about the locations they had searched, and then send one of them inside. Heavy Rescue 1 radioed the IC that they had a good idea of the area that they had searched, and they were going to reenter. Heavy Rescue 1 (Captain and 3 fire fighters) along with a Captain and a fire fighter from Pumper 35, the FAO from Rescue 9, and a fire fighter from a mutual-aid department with a thermal imaging camera (all forming RIT #5), entered the structure to continue the search. Following the ropes back to the area they had just searched, the Captain from Heavy Rescue 1 veered off to his right and found the victim at approximately 1945 hours (see Photo 5). The victim was unconscious, with no helmet, radio, or

SCBA. The Captain immediately yelled to the other fire fighters for assistance in removing the victim from the building. Unable to locate the victim's pulse, the Captain began cardiopulmonary resuscitation (CPR) until the other fire fighters arrived. A radio call was made to the IC informing him that they had located the victim and were removing him. After the radio call, additional fire fighters entered the structure to assist. Fire fighters later stated that the smoke was clearing and the visibility was improved. As they removed the victim, the Safety Officer, who was assisting, tripped and fell over an entanglement of hoselines and ropes. He twisted his knee and also required assistance in exiting.

The victim's helmet was found on the floor in an area where he was operating throughout the fire attack. His SCBA was found approximately 10 feet away from him. He was found equipped with a PASS device, but it was not turned on. *Note: The victim's SCBA cylinder was sent to NIOSH for further testing. The test concluded that the cylinder was empty of breathable air but contained a substantial amount of water (see Attachment 1).*

Fire fighters continued CPR as they loaded the victim into the ambulance where he was transported to a nearby hospital and pronounced dead. The injured Safety Officer received medical treatment for his injuries. Several days after the fire other fire fighters received medical attention for sore throats and breathing difficulties.

CAUSE OF DEATH

The medical examiner listed the cause of death as asphyxia with carbon monoxide inhalation. The victim's CO level was listed at 51%.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Fire departments should ensure that the department's Standard Operating Procedures (SOPs) are followed and refresher training is provided.[1]

Discussion: It is imperative that companies perform their duties as described in the Standard Operating Procedures (SOPs) unless directed or approved by the Incident Commander to do otherwise. According to department SOPs, the following procedures should take place:

- ***Fire fighters should be equipped with and should activate PASS devices during fire fighting operations.***

Department SOPs state that PASS devices should be used and activated whenever the SCBA is worn or whenever the fire fighter is in an area of danger or contamination. PASS devices found deficient in operation or missing should be reported without delay to the Company Officer. If the PASS device is taken out of service, a new PASS device should be issued.

- ***Fire fighters should don their SCBA whenever entering a building for fire fighting operations or for other incidents that require respiratory protection.***

Department SOPs state that fire fighters should always don their SCBA when they enter buildings for fire fighting operations or other incidents that require respiratory protection, to prevent fire fighters from exposure to carbon monoxide or other hazardous gases. Fire fighters should only remove their masks when the fire has been knocked down and the building has been thoroughly ventilated.

- ***Search and rescue activities should be conducted with two or more fire fighters in each group or team and fire fighters should avoid freelancing and always use the "buddy system."***

Department SOPs state that whenever a search or rescue operation takes place, the search and rescue team should consist of a minimum of two fire fighters. Fire fighters should use the "buddy system" at all times during an interior attack, search and rescue operation, confined space operation, or at any time the possibility of being lost or trapped exists.

- ***Fire departments should ensure that a separate Incident Safety Officer, independent from the Incident Commander, be appointed when an Incident Safety Officer is requested.***[2, 3]

According to NFPA 1561, paragraph 4-1.1, "the Incident Commander shall be responsible for the overall coordination and direction of all activities at the incident. This shall include overall responsibility for the safety and health of all personnel and for other persons operating within the incident management system." While the Incident Commander is in overall command at the scene, certain functions must be delegated to ensure adequate scene management is accomplished. A separate Incident Safety Officer should be appointed by the Incident Commander at an emergency incident. *Note: In this incident the District Safety Officer and the Incident Safety Officer are two different positions.* When activities are judged by the Incident Safety Officer to be unsafe or to involve an imminent hazard, the Incident Safety Officer shall have the authority to alter, suspend, or terminate those activities. The Incident Safety Officer shall immediately inform the Incident Commander of any actions taken to correct imminent hazards at the emergency incident. Department SOPs state that an Incident Safety Officer should be on the scene of a reported working fire. In this incident, the Incident Safety Officer responded on the second alarm. Until his arrival, the IC was the acting Safety Officer.

- ***When necessary, the Incident Commander should divide the incident scene into sectors.***

Department SOPs state that when an incident situation exceeds the capability of one officer to effectively manage the entire operation it should be sectored off. Sectors reduce the span of control of the overall command function to more manageable units. Sectors allow the Incident Commander to communicate primarily with sector officers rather than numerous company officers, thus providing an effective command structure. The sectors should be described clockwise from the command post by using letters, numbers, or directional terms (i.e., north, south, east, and west). Smaller operations may be sectored by assigning rear, roof, or interior. Regardless of the specific labeling unit used to sector off an incident, it should be implemented according to SOPs so all fire fighters will be able to communicate effectively. In this incident, the structure was sectored off by north, south, east, and west. The command post was set up on the south side of the structure and they continued to refer to that side as the south side. Throughout the operations fire fighters became confused as to the sectors being referred to, because they misunderstood their positions (i.e., fire fighters who positioned their rig on the north side thought that they were on the south side). Different departments use different labeling systems; however, all fire fighters should be familiar with the system being used.

- ***Lost or trapped fire fighters should manually activate their PASS devices.***

Department SOPs state that fire fighters who become lost or trapped should manually activate their PASS devices to send a signal to the search and rescue teams.

Recommendation #2: Fire departments should ensure that all fire fighters performing fire fighting operations are accounted for.[4]

Discussion: Fire fighters operating in dangerous environments should maintain company or crew integrity and should use the "*buddy system*" as outlined in the department's SOPs. This would require that:

- Company or crew members enter and exit the environment together.
- Members remain within either sight, voice, or tactile distance of each other while they are within the environment. No one should be left alone.
- Incident Commanders and sector officers should not direct members to operate independently of their crews.
- Task assignments should be made through the company officer or crew leader.

Recommendation #3: Fire departments should ensure that proper ventilation equipment is available and ventilation takes place when fire fighters are operating inside smoke-filled structures.[5]

Discussion: When performing an interior fire attack, proper ventilation must take place to release heat and smoke. When operating in large enclosed areas, such as a paper warehouse, smoke can move or shift, causing visibility to deteriorate, sometimes suddenly. "Because of the large open area in a warehouse or storage building, one or two small fans or smoke ejectors will not be effective in removing the large quantities of smoke that can be generated from these fires. The ventilation plan should consider implementing positive-pressure ventilation using gasoline-driven, high-CFM-delivery fans." [5]

Large structures are generally constructed with roof systems that can impede fire fighters' ability to cut ventilation holes. For example, in this incident the roof system consisted of thick layers of metal, rubber, and stone particulate. Fire fighters used gasoline-powered saws, attempting to cut through the thick roof system. Fire fighters used several blades and had to request additional blades to complete partial ventilation (L-shaped cut) before the IC ordered them off the roof. Fire departments should ensure that each piece of apparatus is equipped with the adequate equipment to perform all fireground operations.

Recommendation #4: Fire departments should ensure that one of the first-arriving engines be assigned to pump water into the building's fire department sprinkler connection to reinforce the automatic sprinkler system.[5]

Discussion: Upon arrival of the first-due engines, fire fighters should be assigned to locate the sprinkler system, if the structure is equipped with a system. "One of the assignments should be to check the sprinkler control valve(s) to ensure that they are open and are not closed. The fire fighters should then make a connection, because a fire involving rolls of paper requires copious volumes of water. The engine supplying the sprinkler system should not be on the same main as the engine assigned for manual fire fighting with hoselines."[5]

Recommendation #5: Fire departments should ensure that when entering or exiting a smoke-filled structure, fire fighters follow a hoseline, rope, or some other type of guide.[6]

Discussion: Fire fighters should always try to maintain a sense of direction when performing interior fire fighting operations. When structures become smoke-filled and the visibility is poor, fire

fighters can become easily disoriented. A hoseline, rope, or some other type of guide or reference point can assist fire fighters in maintaining a sense of direction in case an evacuation becomes necessary. Fire fighters should always make a mental note of the location of the closest hoseline, rope, or other type of a guide or reference points in case conditions change.

Recommendation #6: Fire departments should ensure that fire fighters are equipped with a radio that does not bleedover, cause interference, or lose communication under field conditions.[7]

Discussion: Radio communication is one of the most important functions on the fireground. When situations arise on the fireground, radio transmissions need to be clear and timely. Radios need to be reliable, in good working condition, fully charged, ready to use, and free of any interference or bleedover. Fire departments should also take into consideration the frequency on which the radio communication system will operate. The National Fire Protection Association (NFPA) recommends that frequency bands should be separated by 15 kHz in the VHF high band. The separation in the frequencies is to avoid possible interference. Although the department's radios met the NFPA recommended standard for separation of frequencies, there still remains the possibility of bleedover, interference, or loss of communication in certain types of fireground conditions. Before arriving on the scene of this incident, the victim radioed the IC and stated that the radios probably would not work in this type of structure and thought that they would have to use the talk-around channel. Additionally, other fire fighters stated that they never received the evacuation call over the radio. Also, problems were experienced related to water and building penetration factors; both are elements of typical field operations for fire fighters and should not lead to loss of communication.

Recommendation #7: Fire departments should ensure that when fire fighters suspect that they have been exposed to carbon monoxide, they notify their officer or the IC and receive the proper medical care.[6]

Discussion: "More fire deaths occur from carbon monoxide (CO) than from any other toxic product of combustion. This colorless, odorless gas is present with every fire. The poorer the ventilation and the more inefficient the burning, the greater the quantity of carbon monoxide formed. Concentrations of carbon monoxide in air above five hundredths of one percent (0.05 percent) (500 ppm) can be dangerous. When the level is more than 1 percent, unconsciousness and death can occur without physiological signs. Even at low levels of exposure fire fighters should not use signs and symptoms for safety factors. Headaches, dizziness, nausea, vomiting, and cherry-red skin can occur at many concentrations, based on an individual's dose and exposure. Therefore, these signs and symptoms are not good indicators of safety." [6] The table at the end of this report lists the toxic effects of carbon monoxide.[6]

"A 1-percent concentration of carbon monoxide in a room will cause a 50 percent level of carboxyhemoglobin in the blood stream in 2½ to 7 minutes. A 5-percent concentration can elevate the carboxyhemoglobin level to 50 percent in only 30 to 90 seconds. Because the newly formed carboxyhemoglobin may be traveling through the body, a person previously exposed to a high level of carbon monoxide may react later." [6]

If a fire fighter develops any of these signs, he/she should immediately exit the structure and receive the proper medical care. Severe exposures to carbon monoxide can cause nerve injury or brain damage. If a fire fighter is overcome with carbon monoxide he/she should not be allowed to reenter a smokey atmosphere. If a fire

fighter suspects he/she is exposed to carbon monoxide, he/she should notify their officer or the IC (see Table).

Recommendation #8: Fire departments should ensure that a rehabilitation area is designated when needed.[4]

Discussion: During prolonged incidents, strenuous training sessions, and periods of exposure to extreme heat or cold, fire departments should ensure that a rehabilitation area is established. Fire fighters on the fireground can often be exposed to several hazards or risks throughout a long operation. Fire fighters who have become fatigued or exposed to any hazards should be sent to the rehabilitation area. The rehabilitation area should consist of medical personnel who could provide a medical evaluation, treatment and monitoring, and provide fire fighters with food (if necessary) and fluids. The rehabilitation area should be an area for the fire fighters to rest mentally as well as to gain relief from climate conditions. This incident was an extended fire attack coupled with a search and rescue operation.

Recommendation #9: Fire departments should ensure that the assigned Rapid Intervention Team(s) (RIT) complete search and rescue operations and are properly trained and equipped.[8]

Discussion: A RIT should consist of at least two fire fighters and should be available for rescue of a fire fighter or a team if the need arises. The RIT should be fully equipped with the appropriate protective clothing, protective equipment, SCBA, and any specialized rescue equipment that might be needed, given the specifics of the operation under way. Once the RIT is established, they should remain the RIT throughout the operation. They should constantly survey the fireground operations and be in communication at all times with the IC and companies on the fireground. As fireground operations continue, the RIT team should observe the following:

- where fire fighters are entering and exiting
- how many fire fighters are inside
- where the fire fighters are operating
- what operations are taking place
- the layout of the structure
- the structure (i.e., trussed roof, metal roof, etc.) and hazards that could exist with the structure (i.e., possible collapse areas, etc.)
- hazards they might encounter (i.e., chemicals, tanks, etc.)
- the fire's condition (i.e., fire spread, fire in the roof, etc.)
- if an emergency occurs, what will be their best route to enter or exit
- what equipment they will need if an emergency occurs (i.e., airbags, hydraulic jacks, additional air bottles, etc.)

Each incident is different and additional concerns should also be taken into consideration. There are many functions expected from the RIT members during an incident. If an emergency occurs, the RIT should be rested, have full air bottles, a good understanding of the overall situation, and be able to respond in a safe manner to perform the search or rescue. If the RIT is used for an emergency operation, a second RIT should be put in place in case an additional emergency should occur. *Note: Fire departments should ensure that they assess*

all risk factors when making the decision to send a RIT into a structure that has already been the scene of an emergency evacuation, search, or rescue. When a RIT enters a structure, they generally will use a rope or some type of guide to enter and exit. When more than one RIT enters at the same time, more than one rope would be taken into the structure. If multiple ropes are taken into the structure they could possibly get entangled and cause confusion. If multiple ropes are used for search and rescue, a plan of action should be put into place to avoid confusion or the ropes from being entangled.

Recommendation #10: Fire departments should ensure consistent use of Personal Alert Safety System (PASS) devices at all incidents and consider providing fire fighters with a PASS integrated into their Self-Contained Breathing Apparatus.

Discussion: PASS devices are electronic devices worn by the fire fighter, which will emit a loud and distinctive alarm if the fire fighter becomes motionless for more than 30 seconds. Fire fighters entering hazardous areas should be equipped with a PASS device. There are several types of PASS devices available. One device that could be used is a PASS that is integrated into the SCBA. PASS devices integrated into the SCBA will be activated when the SCBA air cylinder is turned on. Manual PASS devices are also used throughout the fire service. These devices require the fire fighter to manually turn on the device each time they use it.

Recommendation #11: Fire departments should develop and implement a preventative maintenance program to ensure that all SCBAs are adequately maintained.[9]

Discussion: Fire departments should establish respirator service and maintenance procedures and rigidly enforce them to provide respirators that are dependable and are constantly evaluated, tested, and maintained. Equally important is recordkeeping, a critical element of any respirator maintenance program. During this incident, several fire fighters stated that they experienced problems with their SCBAs. Based on those statements, NIOSH completed an evaluation of the department's respirator maintenance program on January 19, 2000, and issued a report to the department (see Attachment 2).

The following recommendation applies to building owners, supervisory staff, or employees.

Recommendation #12: Building owners, supervisory staff, or employees should ensure that fires are reported to the fire department immediately.[10]

Discussion: Large, open structures, such as the one involved in this incident, can be extremely dangerous if a fire occurs. The large, open layout allows the fire and smoke to rapidly spread beyond control of the owner, supervisory staff, or employee's attempts to extinguish the fire. Building owners should immediately call the fire department and evacuate the building regardless of whether they think the fire can be controlled or not. If the fire is controlled or extinguished by the owner, supervisory staff, or employees, the fire department could confirm that the fire is completely extinguished and no hot spots exist. This should be written and placed in the structure's contingency plan. The fire department involved in this incident reported that during their pre-fire plan inspections, they advise building owners to immediately notify the fire department if a fire occurs. In this incident, the employees of the warehouse attempted to combat the fire with extinguishers for approximately 15 minutes before notifying the fire department. When the fire department arrived on the scene, they had to spend additional time evacuating employees from the structure.

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8. NFPA [1997]. NFPA 1500: Standard on Fire Department Occupational Safety and Health Program. Quincy, MA: National Fire Protection Association.

9. NIOSH [2000]. Fire Department SCBA Maintenance Program Evaluation Report, NIOSH Ref. #TN-11336, Respirator Branch, Division of Respiratory Disease Studies, NIOSH, Morgantown, WV.

10. NFPA [2000]. NFPA 1201: Standard for Developing Fire Protection Services for the Public. Quincy, MA: National Fire Protection Association.

INVESTIGATOR INFORMATION

This incident was investigated by: Frank Washenitz, Kim Cortez, Tom Mezzanotte, and Mark McFall, Safety and Occupational Health Specialists, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH.

The SCBA maintenance program was investigated by: Tim Merinar, Engineer, and Tom McDowell, Physical Scientist, Respirator Branch, Division of Respiratory Disease Studies, NIOSH.

Expert review was provided by Vincent Dunn, retired Deputy Chief, New York City Fire Department.

Carbon Monoxide (CO)(ppm)	Carbon Monoxide in air (percent)	Symptoms
100	0.01	No symptoms-no damage
200	0.02	Mild headache; few other symptoms
400	0.04	Headache after 1 to 2 hours
800	0.08	Headaches after 45 minutes; nausea,collapse, and unconsciousness after 2 hours.
1,000	0.10	Dangerous; unconscious after 1 hour
1,600	0.16	Headache, dizziness, nausea after 20 minutes.
3,200	0.32	Headache, dizziness, nausea after 5 to 10 minutes; unconsciousness after 30 minutes.
6,400	0.64	Headache, dizziness, nausea after 1 to 2 minutes; unconsciousness after 10 to 15 minutes.
12,800	1.26	Immediate unconsciousness, danger of death in 1 to 3 minutes.

Table. *Toxic Effects of Carbon Monoxide.*[6]

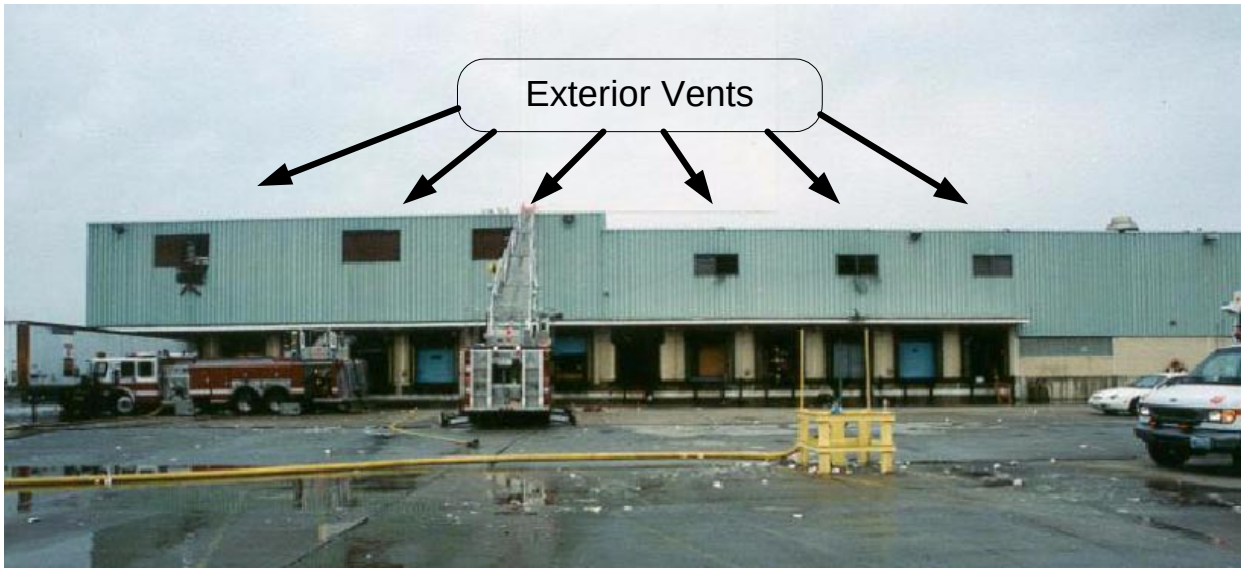

Photo 1. *Exterior View of the Warehouse From the East Side.*

Photo 2. *Paper Bales Which Caught Fire; Area Where Fire Fighters Entered Through the South-End Door With Hoselines.*

Photo 3. *Area Where Victim Was Positioned Before He Became Disoriented.*

Photo 4. *Dock Door Which Some of the RIT Members Entered.*

Photo 5. *Area Where Victim Was Found*

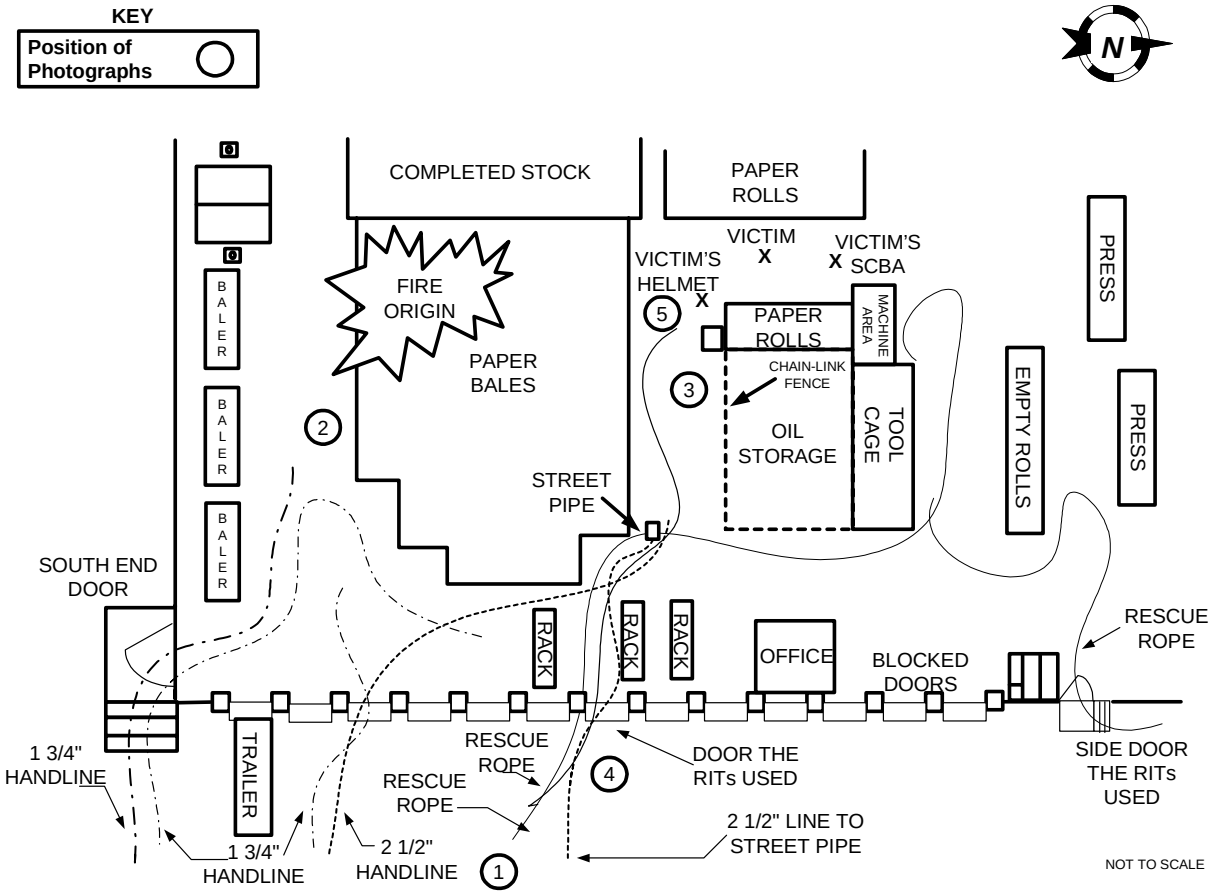

Diagram 1. *Warehouse Interior*

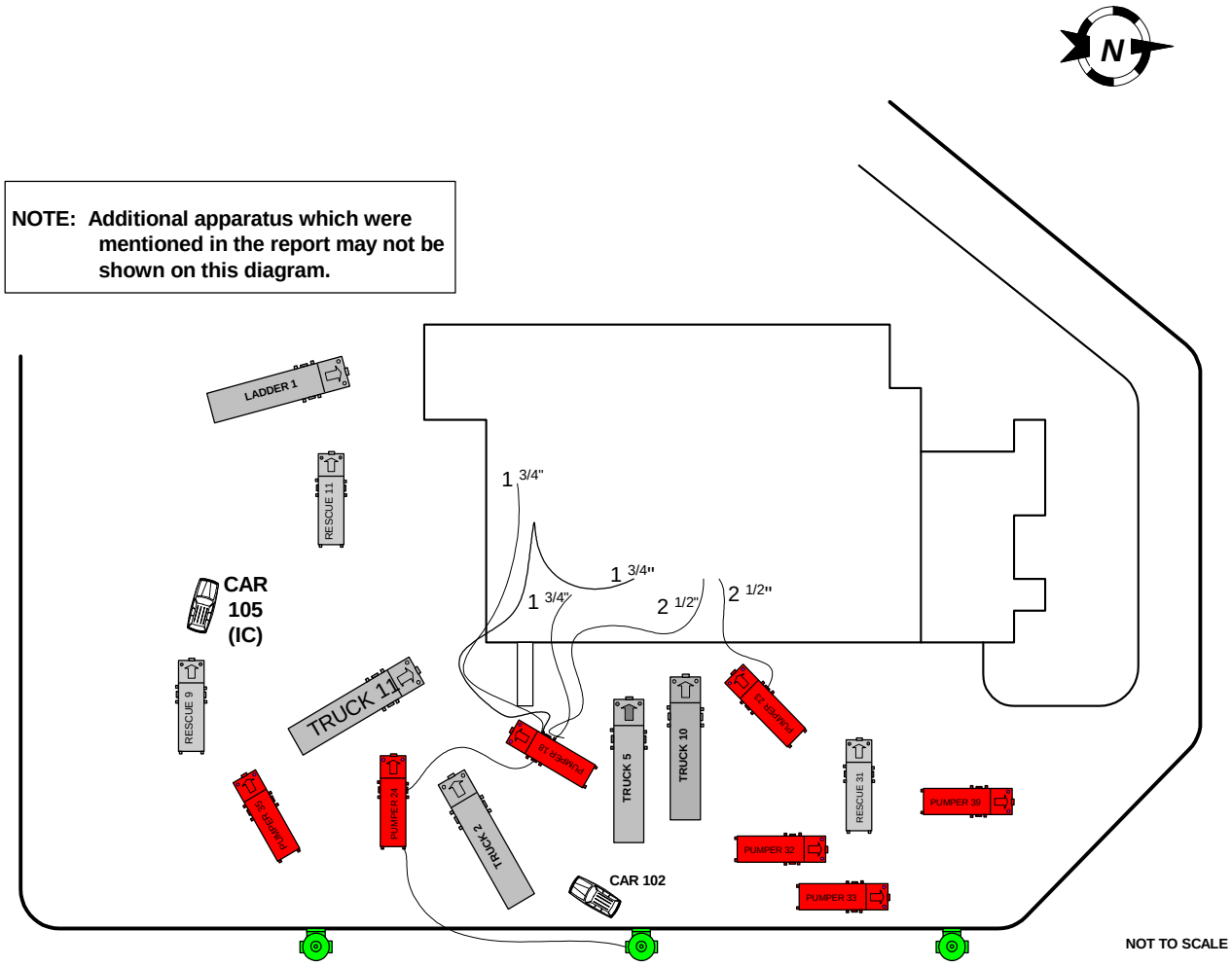

Diagram 2. *Apparatus Layout.*

ATTACHMENT 1

DEPARTMENT OF HEALTH & HUMAN SERVICES — **Public Health Service**

NIOSH Reference: TN-11336

Centers for Disease Control and Prevention (CDC)
National Institute for Occupational Safety and Health - ALOSH
1095 Willowdale Road
Morgantown, WV 26505-2888

Phone: (304) 285-5907
Fax: (304) 285-6030

February 1, 2000

Dear Chief:

The National Institute for Occupational Safety and Health (NIOSH) has concluded its investigation conducted under NIOSH Task Number TN-11336. This investigation consisted of the inspection and testing of one self-contained breathing apparatus (SCBA) shipped to NIOSH by the Fire Department on January 3, 2000. Our inspection report and results of all tests are contained in a detailed Status Investigation Report which is enclosed.

Inspection of the SCBA was completed on January 4, 2000. The SCBA was worn and had the appearance of having seen considerable use. Although the NIOSH approval label was missing, and component part numbers could not be identified on a few component parts, the SCBA appeared to be in the approved condition for a Mine Safety Appliances (MSA) Ultralite, 30-minute, 2216 psi, SCBA (NIOSH approval number TC-13F-138).

The SCBA was thoroughly inspected and determined to be in a condition safe for testing. However, a current hydrostatic test date was not identified on the fiberglass-wrapped composite aluminum cylinder shipped with the SCBA. The cylinder was also found to contain a substantial amount of fluid. It was subsequently learned that the SCBA was left at the fire scene for several days following the fire incident and was immersed in several inches of water. The fluid inside the cylinder is believed to be water which seeped through the pneumatic system of the SCBA and into the cylinder. The cylinder shipped with the SCBA was determined to be unsafe for refilling. A substitute cylinder was obtained from MSA for use during the testing of the SCBA.

The SCBA was tested in the condition as received from the Fire Department (except for the replacement cylinder). The purpose of the testing was to determine the SCBA's conformance to the approval performance requirements of *Title 42, Code of Federal Regulations (CFR), Part 84, Subpart H*. Further testing was conducted to determine conformance to the National Fire Protection Association (NFPA) Air Flow Performance requirements of *NFPA 1981, 1997 Edition*. A series of tests utilizing a Biosystems PosiChek3 computerized SCBA performance tester was also conducted.

ATTACHMENT 1 (continued)

Of the six selected NIOSH tests performed, the unit failed the Rated Service Time Test and the Remaining Service Life Indicator Test. The SCBA also failed to meet the minimum facepiece pressure requirements of the NFPA Air Flow Performance Test. When performance tested using the Biosystems PosiChek3, the unit failed the Alarm Accuracy portion of the Complete SCBA Test.

During the inspection of the SCBA, it was noted that paper fibers were adhered to the facepiece exhalation valve diaphragm. At the time, no effort was made to remove these fibers. During the Rated Service Time Test, the sound of air escaping from the exhalation valve was observed after the cylinder valve was opened, but prior to the start-up of the breathing machine. The unit failed to meet the requirements of the Rated Service Time Test. After the performance testing was completed, the exhalation valve was purged with compressed air to remove the visible paper fibers. The Rated Service Time Test was then repeated. This time, no air was observed to be leaking from the exhalation valve, and the unit met the requirements of the test.

Internal inspections of other individual components requiring disassembly (such as the low air alarm assembly) were not performed.

The status of the SCBA with regard to its conformance to the performance standards prior to the incident cannot be determined. It is quite possible that the test failures observed during this evaluation are a result of damage sustained by the SCBA after the firefighter succumbed to his injuries while fighting the fire on December 18, 1999. For example, the paper fibers affecting the operation of the exhalation valve could have been deposited when the SCBA was submerged in water after the incident. It is also not known what effects, if any, non-conforming SCBA performances would have had at the fire scene. While the unit failed to maintain positive pressure during the NFPA Air Flow Performance Test, the possibility of inward leakage into a firefighter's facepiece would be dependant upon the face to facepiece seal, the ventilation rate at the time of use, as well as other factors such as age, weight, and the physical condition of the firefighter. Test results indicate that air was flowing to the facepiece in a sufficient quantity to support moderate ventilation requirements. It is also important to note that the SCBA facepiece pressure remained positive throughout the NIOSH Rated Service Time Test.

The Personal Alert Safety System (PASS) device shipped with the SCBA was not evaluated by NIOSH. The Institute does not have criteria for testing these units. During the inspection, the PASS unit was manually activated and appeared to operate properly.

It is strongly recommended that this SCBA be inspected and serviced by an authorized MSA service technician, and all necessary overhaul and repair work be completed before placing the unit back into service. It is also recommended that all SCBA inspection, handling, use, and

ATTACHMENT 1 (continued)

maintenance procedures be reviewed with regard to activities and practices that could impact the safe use of all SCBA.

It is important to note that this SCBA is reported to have been left in standing water at the fire scene for several days following the fire incident. Paper fibers were found adhered to almost every component of the SCBA. Water was found in the pneumatic assemblies and inside the SCBA cylinder. It is believed that this contamination occurred after the victim was removed from the incident scene. It is probable that the paper fibers and water had an effect on the SCBA's performance during the testing sessions at NIOSH and compromised the value of this physical evidence.

Therefore, the Institute recommends that the Fire Department review its policies and procedures to ensure the use of proper methods for maintaining the integrity of physical evidence collected during fire investigations. Care should be taken to protect the value of physical evidence from the time of its initial discovery and collection to its subsequent examination and testing. Guidelines for the proper handling of physical evidence can be found in *NFPA 921, Guide for Fire and Explosion Investigations, 1998 Edition, Chapter 9 - Physical Evidence.*

No further action will be taken by NIOSH and the investigation of Task Number TN-11336 will be considered closed. The SCBA will be stored under lock in room 178A of the NIOSH Appalachian Laboratory for Occupational Safety and Health (ALOSH) pending return to the Fire Department.

I trust this information is satisfactory to meet your needs. If you require further assistance, please contact me at (304) 285-6337.

Sincerely yours,

Thomas W. McDowell,
Physical Scientist
Quality Assurance Team
Respirator Branch
Division of Respiratory Disease Studies

ATTACHMENT 2

DEPARTMENT OF HEALTH & HUMAN SERVICES — **Public Health Service**

NIOSH Reference: TN-11336

Centers for Disease Control and Prevention (CDC)
National Institute for Occupational Safety and Health - ALOSH
1095 Willowdale Road
Morgantown, WV 26505-2888

Phone: (304) 285-5907
Fax: (304) 285-6030

February 1, 2000

Dear Chief :

During our visit to the Fire Department on January 19, 2000, Tim Merinar and I had the opportunity to evaluate your fire department's self-contained breathing apparatus (SCBA) maintenance program. The objectives of our visit were to evaluate your SCBA maintenance program and to make recommendations for improvement. This evaluation consisted of visiting the SCBA maintenance area, interviewing fire department personnel associated with the maintenance of SCBA, reviewing SCBA maintenance records and procedures, evaluating the compressed-air cylinder refilling station located at your training facility, examining Air Truck 1, and evaluating the compressed-air and oxygen cylinder refilling stations located at Stations 4, 10, and 18. Our evaluation process benefitted substantially from the cooperation of your staff. Their cooperation was instrumental in providing us with information necessary for the evaluation of your SCBA maintenance program.

Your current SCBA maintenance program was evaluated and compared to the respirator and SCBA maintenance requirements listed in the following recognized national standards:

Title 29, Code of Federal Regulations (CFR) Part 1910.134 known as *The OSHA Respirator Standard.*

National Fire Protection Association (NFPA) 1404, Standard for a Fire Department Self-Contained Breathing Apparatus Program, 1996 Edition.

National Fire Protection Association (NFPA) 1500, Fire Department Occupational Safety and Health Program,1997 Edition

American National Standards Institute, Inc. (ANSI), American National Standard for Respiratory Protection, ANSI Z88.2-1992.

ATTACHMENT 2 (continued)

These standards specify the minimum benchmark requirements that all fire department respirator programs should strive to meet or exceed. Compliance with these standards is considered to be essential to maintain SCBA in a condition meeting the certification requirements of the National Institute for Occupational Safety and Health (NIOSH) found in *Title 42, Code of Regulation, Part 84, Subpart H*, as well as the *National Fire Protection NFPA 1981 Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service, 1997 Edition*. Failure to maintain your SCBA in an approved condition voids the NIOSH approval until such time as each affected SCBA can be inspected, serviced, and returned to an approved condition.

The following areas were identified within the Fire Department SCBA maintenance program as areas where improvement is needed in order to comply with the referenced national standards:

1) The SCBA maintenance program should be under the direct control of one designated individual who is a Fire Department employee and who has no other fire fighting or administrative responsibility. In general, this individual's area of responsibility could be tailored to meet the department's needs, but should include supervision and control of all aspects of the program including the SCBA preventive maintenance program, repair, testing, record keeping, and auditing. Our evaluation revealed that personnel currently responsible for the SCBA maintenance program have responsibilities in other areas.

> *Title 29, Code of Federal Regulations (CFR), Part 1910.134 (the OSHA Respirator Standard) at 1910.134(c)* requires each respirator program to be administered by a suitably trained program administrator.

It was also noted that several persons had access to the SCBA repair and spare parts storage areas. This situation could lead to untrained and unauthorized individuals performing SCBA repair, as well as producing problems with maintaining an accurate inventory of replacement parts.

2) A preventive maintenance program should be established to ensure regularly scheduled preventative maintenance is conducted on each SCBA at least annually. It is noted that the Fire Department does not operate a preventive maintenance program but rather attempts to repair defective SCBA on an as-needed basis.

> The *OSHA Respirator Standard 29 CFR 1910.134(c)(1)(v); 1910.134(c)(1)(vi); and 1910.134(h)* require the employer to develop and implement a written respiratory protection program that includes specific procedures and schedules for cleaning and disinfecting, storage, inspection, maintenance, and repair of respirators used by employees.
>
> *NFPA 1404, Chapter 6-1.2 and 6-1.3* require annual inspection and servicing of SCBA by

ATTACHMENT 2 (continued)

qualified personnel. *Chapter 6-1.3* requires annual servicing to be conducted following the manufacturer's recommendations and should include :

a) Disassembly of the SCBA into major components
b) Flow testing of the regulator
c) Disassembly and cleaning of the regulator
d) Replacement of worn parts, or those recommended by the manufacturer in the regulator assembly.
e) Disassembly of the low-air alarm and cleaning and replacement of component parts as necessary.
f) Cleaning and replacement of components of the facepiece and harness assembly, and replacement of component parts as necessary.
g) Reassembly of the entire SCBA and testing for proper operation of all components.
h) Proper recording of all performed maintenance on record keeping forms.

NFPA 1404, Chapter 6-2.1 specifies that a preventative maintenance program shall be established by the authority having jurisdiction for all SCBA used in the organization.

NFPA 1404, Chapter 6-2.2 specifies that the SCBA preventative maintenance program shall be conducted in order to prevent SCBA malfunction and failures of equipment during use.

NFPA 1500, Chapter 5-3.1 specifies the fire department shall adopt and maintain a respiratory protection program that addresses the selection, inspection, safe use, and maintenance of respiratory protection equipment, training in its use, and the assurance of air quality testing.

NFPA 1404, Appendix A, A-6.2 states that an SCBA should be rebuilt by its manufacturer or by a person trained and certified by the manufacturer at intervals as recommended by the manufacturer.

Specific guidelines for determining and scheduling preventive maintenance actions can best be compiled with assistance from your SCBA manufacturer. Frequency of complete SCBA overhaul should be based on the manufacturer's recommendation. If no manufacturer's recommendation is provided, NIOSH recommends that rebuilding of SCBA assemblies be performed every 3 years.

It is apparent that in order for the Fire Department to establish a comprehensive preventive maintenance program, the department will need to acquire additional resources. It would be

ATTACHMENT 2 (continued)

impossible for your current SCBA maintenance staff to continue to complete repairs as well as perform all tasks necessary for comprehensive preventive maintenance for nearly 300 SCBA.

3) Records should be maintained for each SCBA, facepiece, and cylinder at the department. During our visit, we were shown a card filing system where repair and testing information was maintained for each SCBA and filed according to company assignment. An electronic file had also been developed to help track cylinder hydrostatic test schedules and service life dates. NIOSH recommends that the computerized records system be expanded to address the following standard excerpts:

> *NFPA 1404, Chapter 2-2.3* specifies that an individual record of each SCBA regulator and harness assembly shall be maintained. This record shall include the inventory or serial number, date of purchase, date of manufacture, date placed into service, location, maintenance and repairs, replacement parts used, upgrading, and test performance.
>
> *NFPA 1404, Chapter 2-2.4* specifies that an individual record of each SCBA cylinder shall be maintained. This record shall include the inventory or serial number date of purchase, date of manufacture, date placed into service, location, hydrostatic test pressure and dates, and any inspection and repairs. The hydrostatic test dates shall appear on each cylinder according to the manufacturer's instructions and applicable government agencies.
>
> *NFPA 1404, Chapter 2-2.5* specifies that an individual record of each SCBA facepiece shall be maintained. This record shall include the inventory or serial number, date of purchase, location, maintenance and repairs, replacement parts, upgrading, and test performance.
>
> *NFPA 1500, Chapter 2-7.5* specifies that each fire department shall assure that inspection, maintenance, repair, and service records are maintained for all vehicles and equipment used for emergency operations and training.
>
> The *American National Standard for Respiratory Protection, ANSI Z88.2-1992, Chapter 10.2* specifies that inspection records be maintained for each respirator.
>
> The *OSHA Respirator Standard 29 CFR 1910.134(c); 1910.134(h)(3)(iv)(A and B);* and *1910.134(m)* specify general requirements for record keeping within a respirator program.

4) A program should be developed to ensure that all SCBA cylinders meet the US Department of Transportation (DOT) standards for periodic requalification and service life limitations. These

ATTACHMENT 2 (continued)

standards are listed in *Title 49, Code of Federal Regulations (CFR), Part 173.34(e).* During our visit to Station 18, we observed several SCBA cylinders in service with expired hydrostatic test dates. A review of the records kept at the Training Center verified that several in-service cylinders had past-due hydrostatic test dates. DOT requirements for the composite aluminum, fiberglass-wrapped cylinders utilized by the Fire Department require that each cylinder be submitted every three years to a DOT-certified retester for inspection and hydrostatic testing. The DOT requirements limit the service life for these cylinders to 15 years from the date of manufacture, regardless of the last date of requalification.

> *NFPA 1500, Chapter 5-3.8* specifies that SCBA cylinders shall be hydrostatically tested within the periods specified by the manufacturers and the applicable governmental agencies.
>
> *NFPA 1404, Appendix A, A-6.2* specifies that breathing gas cylinders be tested as prescribed in *Title 49, Code of Federal Regulations (CFR), Part 178, Shipping Container Specification Regulations.*
>
> *Title 42, Code of Federal Regulations (CFR), Part 84.81(a), NIOSH Requirements for Respiratory Protection Devices* requires cylinders used on NIOSH-approved SCBA to meet the minimum DOT requirements.

5) The Fire Department should establish a written standard operating procedure for managing SCBA found to be defective or non-functioning. If a firefighter finds an SCBA in need of service during use or inspection, the SCBA should be identified with a tag displaying SCBA identification, information regarding the defect found or performance problem observed, and appropriate contact information for the SCBA user. This procedure should also cover the methods to be used to remove the SCBA from service and to refer the problem to the appropriate SCBA maintenance personnel. All service performed on the SCBA should then be documented in the records system.

> The *OSHA Respirator Standard 29 CFR 1910.134(c)(1)(v) and 1910.134(h)(4)* require the employer to develop schedules and procedures for inspecting respirators and ensuring that respirators that fail inspection or are otherwise found to be defective are removed from service.

6) Inspections should be conducted at least weekly and preferably at the beginning of each work shift and after each use to ensure that each SCBA is checked for proper function. During our visit, you indicated that each SCBA is inspected at the beginning of each work shift but that a written record detailing cylinder pressure, hardware condition, name, date, and other pertinent information regarding the inspection of each SCBA is not kept.

ATTACHMENT 2 (continued)

The *OSHA Respirator Standard 29 CFR 1910.134(h)(3)* lists the requirements for respirator inspections. *1910.134(h)(iv)(A and B)* list the requirements for documenting each inspection.

NFPA 1404, Chapter 5-1.2 specifies that where fire apparatus is in daily use, an inspection of all respiratory protection equipment and reserve cylinders on each apparatus shall be conducted at least daily.

The *American National Standard for Respiratory Protection, ANSI Z88.2-1992, Chapter 10.2* specifies that the SCBA user shall inspect the respirator, and that a record of inspection dates shall be kept for each respirator.

7) Annual evaluations of the SCBA Maintenance Program should be conducted to monitor and evaluate the effectiveness of the overall SCBA maintenance program.

The *OSHA Respirator Standard 29 CFR 1910.134(h)(3)*(1)(ix) requires the employer to develop and maintain as part of the overall written respiratory protection program, procedures for regularly evaluating the effectiveness of the program.

NFPA 1404, Chapter 8-1.1 specifies that the authority having jurisdiction shall review the organization's respiratory protection program annually for the purposes of determining the need to upgrade or change various aspects of the program.

These recommendations are based upon the premise that all SCBA are life-saving devices which will only perform as well as they are maintained. Since they are expected to function and perform properly each time they are used, it is important that SCBA maintenance and inspection be given the utmost priority at the department level.

During our visit, we provided your SCBA maintenance personnel with a copy of the peer-reviewed document Respirator Maintenance Program Recommendations for the Fire Service developed by NIOSH and published in the Journal of the International Society for Respiratory Protection. We also provided draft copies of generic standard operating procedures and record keeping forms that may assist you in developing improvements to your overall SCBA maintenance program.

During our visit, we also inspected and evaluated three oxygen cylinder refilling stations located at Stations 4, 10, and 18. Oxygen cylinders are typically refilled for use in oxygen resuscitators and other emergency medical equipment used to administer oxygen therapy. The *OSHA Respirator Standard 29 CFR 1910.134* as well as the *NFPA 1404 Standard for a Fire Department Self-*

ATTACHMENT 2 (continued)

Contained Breathing Apparatus Program, do not specifically address these types of medical devices. However, safe handling practices dictate that oxygen refilling systems as well as oxygen equipment be stored in a clean, dry, air-conditioned location that is locked to limit access only to those individuals who have been properly trained and qualified to work with oxygen equipment. All cleaning, repair, and refilling operations should be conducted using the appropriate special tools which are cleaned, maintained, and dedicated only for use on oxygen equipment. The oxygen cylinder refilling stations that we examined failed to meet the above requirements.

The NIOSH Fire Fighter Injury Investigation Report 98F-23, *Oxygen Regulator Flash Severely Burns One Fire Fighter - Florida*, and the joint FDA and NIOSH Public Health Advisory: *Explosions and Fires in Aluminum Oxygen Regulators* both contain a number of recommendations on safe handling procedures for handling and filling portable oxygen cylinders. Both documents address special precautions which should be taken for oxygen cylinder filling stations. A copy of each document is enclosed.

The *Compressed Gas Association pamphlet CGA G-4 (1996 revision) Oxygen* (especially chapter 4) and the *NFPA 53 Guide on Fire Hazards in Oxygen-Enriched Atmospheres, 1994 Edition* are also excellent sources of information on oxygen cylinder storage and safe handling procedures.

I trust this information is beneficial to your needs. If you have any questions or require additional information, please contact me at (304) 285-6337.

Sincerely yours,

Thomas W. McDowell
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