

# Firefighter Safety and Health Issues at the World Trade Center Site

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## INTRODUCTION

The rescue effort which began at the World Trade Center (WTC) complex on September 11, 2001 demonstrated to the world the unparalleled bravery and dedication to service of the New York City Fire Department members. Three hundred and forty-three firefighters died in the attack and more than 200 were seen in emergency rooms for physical trauma [Kelly, 2002a]. The Fire Department of New York (FDNY) led the rescue and evacuation of thousands of civilians from the Twin Towers and surrounding endangered buildings. The Fire Department utilized its entire Incident Command Structure (command, operations, planning logistics, finance) to control and coordinate rescue and recovery operations. It also coordinated the efforts of construction workers using heavy demolition equipment (front-end loaders, excavators, cranes, grapplers, etc.) to remove mountains of steel and building debris after the collapse of the Twin Towers and WTC 7. In a frantic attempt to find survivors, firefighters courageously positioned themselves in very close proximity to these demolition machines, manually digging in areas containing mounds of unstable debris. Void searches and confined space entries were conducted under the shadows of damaged buildings and pedestrian bridge structures without required safeguards in place. As the rescue effort continued through the night, portable stadium lights were obtained through the Mayor's Office of Emergency Management (OEM). These lights are still in place at Ground Zero to

enhance visibility during inclement weather and to permit operations to continue at night.

The FDNY Bureau of Health Services (BHS) physicians responded immediately to the scene and a triage area was established on Broadway. However, the threat of collapse of WTC 7 building resulted in its relocation to the Pace College building in the same afternoon. At the outset, many firefighters complained of eye irritation, cough, and congestion as the air was heavily contaminated with particulate matter from the collapse of the Twin Towers and WTC 7 [Kelly, 2002a].

Shortly after September 11th, the FDNY BHS teamed with representatives of the National Institute of Occupational Health and Safety (NIOSH) and the Center for Disease Control and Prevention (CDCP) to develop a Medical Monitoring Program for all members, in order to compare current results with past annual medical exams. Each firefighter filled out a computerized survey to provide exposure data (days worked at the WTC, tasks performed, etc.). Tests were also performed to evaluate firefighter hearing, lungs, blood, and urine [Kelly, 2002a].

Within days after the attack, the Mayor's Office, solicited the San Francisco-based Bechtel Construction Company to evaluate safety conditions at Ground Zero and draft an accident prevention plan. By mid-October, Bechtel with assistance from the designated Project Manager of the Department of Design and Construction (DDC), the New York Department of Health, the Port Authority of NY and NJ (PA), New York State Department of Environmental Conservation (DEC), the Occupational Safety and Health Administration (OSHA), and the Environmental Protection Agency (EPA) produced the Environmental, Safety, and Health (ESH) Plan for the WTC Emergency Project. The ESH Plan defined the minimum acceptable requirements for ensuring worker safety and health at the WTC for all operational agencies. The FDNY, leading the Search, Rescue, and Recovery effort was given the responsibility for the implementation, enforcement, and compliance with the plan.

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Furthermore, other ESH-related codes, standards, regulations, and requirements of the DDC, DOH, and DEC were to be strictly enforced. Finally, OSHA standards superceded any and all items referenced in the ESH Plan.

“The World Trade Center site is potentially the most dangerous workplace in the United States” [Henshaw, 2001]. John Henshaw, Assistant Secretary of Labor for OSHA made this statement at a November 20, 2001 meeting called to organize a cooperative effort in ensuring a safe and healthful workplace for all persons working at the site. Representatives of OSHA, DDC, the Buildings and Construction Trades Council of Greater New York (BCTC), Building Trades Employers’ Association (BTEA), Contractors Association of Greater New York (CAGNY), General Contractors Association (GCA), the Prime Contractors for the WTC Project, and the FDNY Site Safety Officer (SSO) who is the liaison with all federal, state, and local safety and health agencies, worked together and signed the WTC Emergency Project Partnership Agreement.

**METHODS**

Safety and health procedures outlined in the Emergency Safety and Health Plan for the WTC Emergency Project are as follows: site orientation and training; personal protective equipment (PPE); fall protection; heavy demolition equipment safety; confined space entry; hazardous material management; dust suppression; weapons, ammunition, and explosives; manual lifting safety; and rehabilitation, creature comforts, and counseling [Spadafora, 2002].

**Site Orientation and Training**

All site employees were required to attend an orientation training session given by the Center to Protect Workers Rights (CPWR), a research arm of the Building and Construction Trades Department, AFL-CIO, prior to beginning work at the WTC. This program included all workers entering the perimeter of the site. Due to their unique duties, firefighters were to receive orientation training that was developed and conducted under the direction of the SSO. It must be noted that the entire FDNY was utilized at one time or another to assist in this effort. It was critical that they were familiarized with Incident Command, procedures, hazards, and personal protection equipment. The elements of that training are presented in Table I.

**Personal Protective Equipment (PPE)**

On Day 1 of the attack, rescue workers were given dust masks by the New York City Department of Health (NYCDOH) to use in place of self-contained breathing apparatus (SCBAs) that were inappropriate for debris removal. The dust masks were an initial attempt to protect

**TABLE I.** Elements of Orientation Training for Firefighters at the World Trade Center Site

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- Responsibilities of the Chief Safety Officer (three designated Battalion Chiefs per shift)
- Confined space entry requirements
- Counseling resources
- Crane safety
- Demolition hazards and collapse zones
- Electrical safety
- Emergency site evacuation procedures
- Emergency Medical Service (EMS) locations
- Emergency safety and health plan requirements
- Exclusion work zone/restricted work zone protocol
- Fall protection
- General site orientation
- Global positioning satellite (GPS) system procedures
- Heavy demolition equipment safety
- Manual lifting safety
- Motor vehicle (apparatus, ATV, gator) regulations and speed limits
- Night work safety
- No eating, drinking, or smoking on the debris pile
- Ordnance, ammunition, and explosives recovery protocol
- Personal protective equipment (PPE) requirements
- Physical hygiene and decontamination
- Recovery Team removal procedures
- Rest and rehabilitation requirements and facility locations
- Site hazards (biological, chemical, and physical)
- Site security
- Spotter (debris removal observer) guidelines and safety requirements
- WTC fire prevention bulletin regulations

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firefighters from inhaling airborne contaminants. Within 72 hr, the New York State National Guard trucks were delivering half face respirators to the site. OSHA personnel conducted manual seal fit tests on firefighters during respirator distribution. By the week’s end, the FDNY had acquired SCOTT AV 2000 Facepiece air purifying respirator (APR) adapters to provide members with an alternate choice of respiratory protection.

When it was instituted, the ESH plan required that all firefighters engaged in the recovery operation wear the following minimum PPE: helmet (preferred) or hard hat; safety glasses or goggles; bunker coat and/or high visibility vest; full length trousers/coveralls and long sleeve shirt; work gloves and latex gloves (removal operations); steel toed heavy-duty work shoes; foam ear plugs (in areas where noise level is measured at or above 85 dB); half face respirator with triple combo (dust, organic vapor, acid gas) cartridges.

As of December 2001, more than 2,700 firefighters were given a Quantitative Fit Test performed on an OSHA PORTA COUNT machine. The machine measures the concentration of room dust both inside and outside the respirator mask

thereby establishing the effectiveness of the seal and filters on the firefighters individually issued respirator. OSHA personnel also presented the limitations of respirators: they do not supply air, so they are useless in an oxygen deficient atmosphere (void searches and confined space entry scenarios); filters can become clogged, making it harder to breathe, and cartridges, therefore, should be changed daily. Even triple combo cartridges do not filter out all potentially hazardous gases in the air. Members were instructed to avoid areas where steel cutters are burning, generating toxic clouds of yellow smoke.

### **Fall Protection**

OSHA standards require workers to be protected from falls at elevations more than six (6) feet above ground. Conditions on the debris pile could change on an hourly basis requiring frequent discussion by the SSO and the FDNY Operations Chief regarding the placement of fall protection. The Prime Contractor Safety Rep responsible for a given area would have the primary protective systems, Jersey (concrete) barricades and wooden barriers, which were moved to appropriate locations. When primary fall protection systems could not be installed due to the terrain, the Chief Safety Officers were to identify fall hazards and instruct Recovery Team Leaders (company officers) to have members back away from exposed edges. Chief Safety Officers had authorization to suspend all operations if debris/rubble piles began to shift or falling debris from surrounding structures became a hazard.

### **Heavy Demolition Equipment Safety**

All Recovery Team personnel were instructed to keep a minimum of fifty (50) feet away from the operating radius of debris removal equipment. Additionally, in areas of known instability (Restricted Work Zones) established by structural engineers, recovery operations were strictly limited to one spotter per machine who observed debris removal equipment and its operation.

### **Confined Space Entry Protocol**

A confined space is defined as a space (pipe, duct, tank, excavation, tunnel, vault, conduit, pit, void, or recess etc.) large enough for a person to enter and perform work. It has a restricted means of entry or exit and is not designed for continuous occupancy. Any void or recessed area uncovered by demolition operations was evaluated by the FDNY Special Operations Command (SOC) prior to entry. Contractor or agency personnel seeking entry into confined spaces which have the potential to contain a hazardous atmosphere, dangerous physical configuration, or any other recognized serious safety/health hazards were required to submit a

written plan (permit which is reviewed by SOC and engineers from DDC). The FDNY was to be notified 24 hours in advance for all permit-required confined space entries. SOC will determine whether an FDNY escort is required. If not, SOC will either monitor entrant activity from outside the entrance with retrieval devices, lifelines, and/or mechanical lifting equipment or allow the contractor/agency to provide their own trained employees as attendants.

### **Hazardous Material Management**

A wide variety of different chemical substances, compounds, and associated wastes used in maintenance and janitorial operations were stored at the WTC. Material safety data sheets (MSDS) for all chemicals were obtained by the SSO from the Port Authority. The PA also supplied Chemical Inventory Lists for each building inside the WTC complex. This information was needed when unmarked containers (cylinders/drums) were uncovered by demolition machinery on the debris pile. Undamaged containers were removed by the FDNY to designated steel cages located at safe areas where they are examined and identified by the EPA and taken from the site. The FDNY Hazardous Materials Unit was called to respond by the Operations Chief for mitigation purposes when damaged/leaking containers were encountered. They worked in conjunction with on-site SOC personnel and the EPA.

### ***Fire prevention bulletins***

Fire prevention bulletins, formulated by the FDNY Fire Prevention Bureau (FPB) specifically for the WTC Project, enabled the Fire Department to safely manage steel cutting and welding operations. They also regulated the transportation, storage, and use of flammable and combustible liquids and gases. Tube trailers, containing large amounts of compressed oxygen and portable liquid oxygen cylinders were included in our enforcement policies. Bulletins were distributed to FDNY personnel at general meetings. Bureau members were detailed to enforce these bulletins and interact with demolition and construction personnel.

### **Dust Suppression**

The tremendous amount of debris and dust at Ground Zero contained many contaminants (asbestos, metals, silica, organic compounds, and aromatic hydrocarbons) to name just a few. The prime contractors utilized water tankers for dust suppression on the debris pile to safeguard workers and the surrounding community. Although the primary focus of the FDNY was on extinguishing fires uncovered during the debris removal process, fire fighters did assist in this operation with the use of tower ladder streams, multiversals, and hoselines.

## Weapons, Ammunition, and Explosives Protocol

WTC 6, the Customs House, contained two pistol ranges (B-1 and B-6 sub-levels). Approximately one million rounds of live ammunition were stored inside these ranges. Ammunition consists of case material (brass or aluminum), a lead projectile, a primer, and propellant. When exposed to fire or temperatures above 392°F, the primer and propellant can ignite, causing the case to fragment and act as a low velocity projectile. It is also possible to strike the primer and cause the ammunition to discharge. Recovery Team members examining the rubble in these selected areas were issued full-face shields for optimum eye protection. All weapons discovered were assumed to be loaded; explosives were not touched. Firefighters were to evacuate the area with a minimum of one hundred (100) feet in all directions and notify the Port Authority Police Department or the NYPD immediately through the FDNY chain of command. The cutting of steel in areas where weapons, ammunition, and explosives (small amounts used by PA police to train dogs) were located was strictly regulated.

## Manual Lifting Safety

Recovery Teams handled, lifted, and moved objects of varying weights and sizes. Improper manual lifting can cause back pain and injury. Proper lifting techniques were stressed during Orientation Training and included:

- Restrict lifting in a kneeling/crouched position to minimum weight and repetition.
- Keep loads centered and close to the body.
- Avoid repeated one hand lifting.
- Arrange lifting tasks to keep the load between knuckle height (arms hanging at sides) and shoulder level.
- Avoid twisting motions during load transfer.
- Take breaks a minimum of every 2 hr.

## Rehabilitation, Creature Comforts, and Counseling

Firefighters were working heroically over an extended period of time in an extremely hostile environment under less than ideal safety conditions. The physical demands made upon them and levels of personal stress were unbelievable.

The American Red Cross and Salvation Army arrived at Ground Zero on the first day of the operation to supply much needed moral support, food and beverages, and dry clothing. They supplemented overburdened EMS workers by providing first aid to injured firefighters and workers exhibiting symptoms of heat stress (cramps, muscle aches) and heat exhaustion (headache, vomiting, and nausea). Saline eye

wash solution and plastic bandage strips to cover minor cuts and blisters were other valuable supplies provided.

During unusually warm or cold weather, the SSO notified the FDNY Operations Chief of the need for timely and additional relief periods for Recovery Team members. In warm weather, firefighters were directed to shelters/rest havens away from the debris pile where cold drinks were available for rehydration. Cold stress and hypothermia are concerns during the cold winter months. Cold stress can cause workers to be distracted, preoccupied, and irritable. Symptoms of hypothermia include poor coordination, impairing a firefighter's ability to work safely. To counteract the ill effects of cold weather, members were supplied with insulated underwear and coveralls. Sweatshirts were also issued for additional clothing layers required by low temperatures. Warm-up shelters supplied by electric heaters were located throughout the site. Food and warm beverages were made available to all workers courtesy of the Salvation Army at a lightweight metal and canvass structure known as the Biosphere or Taj Mahal.

The FDNY Counseling Unit (CSU) immediately mobilized its staff and established satellite units in Staten Island and Goshen, New York. Our counselors were supplemented by International Association of Fire Fighters (IAFF) peer counselors and retired peer counselor volunteers. Sixty-three fire units lost members in the attack on the WTC. Initially, counselors were placed in these units to offer small group discussions and allow members an opportunity to talk. In the month following the terrorist attack, more than 1,000 people sought assistance from the CSU. The CSU is continuing to serve firefighters and their families today [Kelly, 2002b].

## RESULTS

Ground Zero was initially a rescue effort, and subsequently a recovery operation and crime scene under the jurisdiction of the NYC OEM. The NYC Department of Design and Construction and the FDNY were assigned as co-incident commanders. The complexity of the activity performed at one site—rescue, recovery, demolition, and construction—at one time is unprecedented. Heavy equipment of all types (crawler cranes, grapplers, excavators, backhoes and bulldozers, and hundreds of trucks) was present on site 24 hr a day while rescue and recovery operations were being conducted. Fires burned beneath the rubble for the first 4 months of the operation. Helicopters using thermal imaging cameras revealed underground temperatures ranging from 400 to more than 2,800°F. The fires underground were finally declared “extinguished” by Governor George Pataki on December 19, 2001 [Vincoli et al., 2002]. Over 1.8 million tons of steel and debris were removed along with 1.2 million rounds of stored ammunition and 3,600 pounds of lead-acid batteries. The presence of hazardous materials such as Freon (~200,000 lbs) had to be addressed on a daily basis. Gasoline

(1,000 gallons) and diesel fuel (72,000 gallons) also needed to be recovered from the site during the course of operations. Over 1,000 automobiles were removed from underground parking garages under the WTC [Clark and Mendelson, 2002].

## Injuries

After over 1,000,000 work hours, no firefighter fatalities occurred at this site and none of the reported injuries were life threatening. FDNY Human Resources Information System (HRIS) injury statistics from October 1st, 2001 to April 30th, 2002 (212-day period during the FDNY Recovery Operation), reveal the type and frequency of injuries sustained at Ground Zero (Table II) [Headley, 2002].

## Medical Monitoring

The FDNY BHS analyzed medical data gathered during physical examinations administered to firefighters from early October to the end of January, 2002 and compared it to their annual medical evaluations. Almost 10,000 firefighters, fire officers, EMTs, and paramedics were seen.

## Hearing

Audiometry was evaluated and compared to prior tests. About 7,300 members had acceptable levels and did not have significant changes as defined by OSHA. About 2,200 members had changes and/or abnormalities as defined by OSHA. Most changes or abnormalities were not severe.

**TABLE II.** Type of Injuries Sustained by FDNY Members, October 1, 2001–April 30, 2002

Injury category	Number	Percentage
Sprains/strains	67	33.16
Respiratory	52	25.7
Orthopedic	13	6.43
Neurology/stress	13	6.43
Contusion (closed wound)	10	4.95
Fracture	10	4.95
Cardiovascular	6	2.97
ENT	6	2.97
Gastrointestinal	6	2.97
Laceration (open wound)	6	2.97
Dermatology	4	1.98
Head trauma	3	1.48
Crushing injury	2	0.99
Other conditions	2	0.99
Abrasion/bites	1	0.49
Burns/scalds	1	0.49

## Pulmonary

Nearly 25% of members noticed cough and congestion since working at the WTC but most remained on full duty. Nearly all members had normal chest X-rays that were unchanged from prior films. Of the nearly 1,000 pulmonary function tests, roughly 7,000 were within the normal range. About 2,600 had a change or minimal abnormalities as defined by OSHA (15% decrease)/American Thoracic Society criteria and less than 70 members had moderate to severe abnormalities.

## Blood and urine

Blood work included CBC, chemistries (liver, kidney, and cholesterol), and toxicology (heavy metals and PCBs). CBC results were consistent with results from pre-WTC medicals. Only seven members tested above the normal lead level (25 mcg/dl) for adults. Only two members tested above the normal mercury level (less than 35 mcg/g creatinine) for adults. Beryllium, a metal found in older fluorescent light bulbs and electrical equipment was found to be elevated (1 mcg/l in non smokers; 2 mcg/l in smokers) in only one member. In the United States, average levels of PCBs are below six parts/billion (PPB). At the WTC medical, the average level was less than six PPB. Five percent (480 members) of the 10,000 members tested had levels above six PPB and the average normal level was nine PPB. Thirty-six members had levels above 12 PPB and three of the 36 had levels above 30 PPB.

## Conclusion

As of May 31, 2002 over 19,000 human remains have been found by Recovery Team personnel. More than 1,100 victims have been positively identified [FDNY Incident Action Plan (IAP), 2002]. Recovery operations at Ground Zero are scheduled to conclude in June. Hopefully, continued medical examinations of the human remains will substantially increase the number of victims identified in the near future for the comfort of loved ones.

## LESSONS LEARNED

- Safety controls must be instituted by the uniformed services for the protection of the rescuers no matter how great the life hazard. Proper safeguards enabled firefighters to continue their rescue and recovery work after 9/11 for a 9-month period without a death or life-threatening injury. Safety measures designed to protect firefighters from breathing airborne contaminants, falls, and being struck by heavy equipment were a key factor in government officials allowing the recovery effort to continue throughout the debris removal operation.

- The SSO role in the FDNY's Incident Command Structure is a crucial one. This position must be filled immediately at the scene of a terrorist attack or similar event. The SSO acts as a liaison with federal, state, and local health and safety professionals.
- Utilize battalion chiefs as Safety Chiefs in designated sectors thereby reducing the burden of the SSO. They should be readily identified by a vest or printed logo attached to their outer garments and act as the eyes and ears of the SSO to insure overall coordination. They are the go-to people for construction supervisors and safety professionals when immediate issues arise.
- Schedule an adequate number of Safety Chiefs on duty at any given time.
- Limit the number of days and hours per tour that operational firefighters are allowed to work during prolonged operations. At the WTC, firefighter details were for 30 days only; they were also limited to 12 hr shifts to reduce physical and psychological stress.
- Provide mandatory counseling for all members at the conclusion of their work detail. Visits to the CSU should not be an option because those who may be in need of help may deliberately avoid outreach programs.
- Firefighters must be informed of the dangers in their work environment prior to the start of the detail, when possible. Orientation training is vital at prolonged operations.
- A universal-fit respirator cartridge should be available to rescue workers. Different types of refill cartridges were issued to firefighters but they only fit one specific type of respirator, thereby confusing workers unfamiliar with their use. This was detrimental to the rescue effort in the initial days at the site. A universal adapter that fits onto a SCBA should be designed for a quick changeover from positive pressure air to respirator use.
- Respirators should have built-in voice emitters to enhance communication as it is very difficult to hear someone talking through a respirator. Rescuers constantly removed respirators to converse with fellow workers or to talk into their handie-talkie radios.
- A lighter PPE ensemble (hard hat, military fatigues/boots, safety glasses/goggles) for rescue and recovery workers must be made readily available. Traditional firefighting clothing (helmet, bunker coat/pants, steel-toed/shank boot) is not compatible with void search and debris removal activity. Storage bins containing non-fire environment clothes should be installed on fire apparatus and stored in depots throughout the city for rapid deployment.
- Provide an adequate supply of tools and equipment specifically made for removing rubble and debris. Initially, firefighters were using traditional tools (hooks, halligan, axes) for digging. Subsequently shovels, rakes, pry bars, and entrenching tools were acquired or donated thereby improving digging operations significantly.
- Utilize the FPB personnel to monitor building construction, demolition, and major renovation work in order to check for hazards and violations on-site and around the periphery.
- Utilize volunteer physical and massage therapists to rejuvenate exhausted rescue workers. Maintain an on-call list for future use.
- Investigate all injury incidents to determine cause and evaluate safety measures which were in place. Develop appropriate safety protocols to prevent similar occurrences. Photograph accident scenes when workers are seriously injured.
- Review all injury reports for accuracy and to spot injury trends.

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## NOTE

Deputy Chief Ronald Spadafora responded to Ground Zero from home via the FDNY mustering site located in Flushing, Queens (Shea Stadium) on the morning of September 11, 2001. In October 2001, he was detailed to the WTC Incident Command and designated the FDNY SSO having ultimate responsibility for the safety and well being of all Recovery Team personnel. Chief Spadafora is a 24-year veteran, promoted to Deputy Assistant Chief in August 2002, and designated Assistant Chief of Fire Prevention. He holds a Masters of Professional Studies degree in Criminal Justice from LIU-C.W. Post Center; a Bachelor of Science degree in Fire Science from John Jay College; and a Bachelor of Arts degree in Health Education from Queens College. A former adjunct instructor of Fire Science at John Jay College, he is currently an instructor for Fire Technology, Inc.

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