



## Engineering Sciences Section - 2012

### C27 Lessons Learned About Spray Fireproofing Systems From the World Trade Center Collapse

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After attending this presentation, attendees will: (1) understand how to investigate fireproofing systems; (2) will know about the fireproofing failures that contributed to the WTC collapse, standards developed for spray fireproofing; and, (3) will learn about needed changes to building codes and standards for installation of fireproofing materials.

This presentation will impact the forensic science community by improving the understanding of failure modes for spray fireproofing systems.

Over a ten year period, during investigation of the spray fireproofing systems, many spray fireproofing deficiencies were discovered in the World Trade Center (WTC) towers. Failures occurred due to design errors, installation problems, and maintenance issues. Some of the observed failures affected those highly stressed members that failed causing the collapse of the towers including: the connection between the long span joists supporting floors and the outside walls, the long span joists themselves, and interior core columns. It should be remembered that the towers stood despite the damage inflicted by the planes. It was only after the fires started by the planes that burned long enough to weaken the structural steel that the towers fell. This presentation will describe the investigative techniques used and provide photographic documentation of the observed problems. Experiences during application of spray applied materials during construction of the World Trade Center towers, as well as other buildings, led to development of standards regarding the suitability of spray fireproofing materials for use in buildings and their initial installation. Unfortunately, spray fireproofing materials are relatively fragile and become damaged during later construction activities; and then during occupancy of a building. Additional standards are needed to insure the continued utility of fireproofing systems following their initial application. The importance of these issues has been underscored by the WTC collapse.

Mineral fiber spray materials in common use since early in the Twentieth Century as acoustical treatments were made completely from inorganic materials so they were fire-resistant and were also good insulators. In 1917, ASTM developed a full scale fire test, now standard E119, to determine if structural elements would survive a fire, and if so for how long. A vigorous mineral fiber industry, looking for new markets, applied sprayed mineral fiber acoustical materials to structural steel elements and subjected them to the ASTM E119 fire test. It was discovered that when tested, these materials were sufficiently rugged, temperature resistant, and survived a fire long enough to meet building code requirements. This discovery made high rise construction more efficient and less costly helping to spur the post-war high-rise building revolution into high gear, including the building of the World Trade Center towers.

However, all this was not without problems. Serious application problems with spray fireproofing materials existed at the time of construction of the WTC towers. Sometimes spray mineral fiber materials would fail to stick to the surface of the steel members and simply fall off. This happened to the spray material on the core columns, the columns that buckled in Tower one, where the fire protection fell off in story high sheets exposing the naked steel to fire conditions. Sometimes the spray material would be too thin or have insufficient density to adequately insulate and protect the steel from fire. In the WTC towers, spray fireproofing was found to be either completely missing or too thin to protect critical structural members in many locations, such as the highly stressed ends of the long span joists and their connection at the outside walls, the location where the floors in the fire areas of the towers fell helping to initiate a progressive collapse. In 1977, years after the WTC towers were completed; ASTM developed standard E-736 that set forth tests for adhesion and cohesion, and Standard E-605 to measure thickness and density. Had these standards been in place at the time of the WTC construction it is likely that the observed deficiencies would have never occurred.

In 1980, standards were developed to test the suitability of a spray applied material for use for fire protection of steel; however, the work on standards and regulation governing the use of spray fireproofing materials is not complete. Buildings that pre-date the standards, damage during construction and occupancy still need to be addressed.

**World Trade Center Collapse, Fireproofing, Building codes**