Wet Bench Fire Suppression with Fine Water Spray

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Introduction

Fires involving polypropylene wet benches in cleanroom environments have caused significant losses in the semiconductor industry. This abstract concerns with the suppression of wet bench fire with a Fine Water Spray System. Previous work and the initial "free-burn" test with a polypropylene wet bench under a fire products collector strongly suggested that detection and suppression of wet bench fire could and should be carried out in the early stage of the fire (Ref. 1 and 2). A full-scale simulated cleanroom facility was built and a series of fire suppression tests were conducted with a fine water spray system. The results show that a fine water spray system can be used effectively to extinguish wet bench fire in its early stage.

The Simulated Cleanroom Facility

The simulated cleanroom facility was designed to provide a realistic flow environment around the wet bench. The inside dimensions of the room were 3.7 m wide x 5.5 m long x 3.7 m high. The floor was raised about 1.2 m to accommodate two nominal 8,000 CFM blowers to generate a downward flow of about 60 FPM in the room. On the roof, a porous steel plate with 6.3 mm perforations and 6% open area was placed on the cross beams. An identical layer of porous plate was also placed below the floor. The floor was constructed with close mesh 12 gauge steel grating. A conventional fire retardant polypropylene wet bench was used near the center of the wall. A third blower was connected to the wet bench to provide a secondary flow rate of up to about 1,000 CFM. The wet bench has dimensions of 1.4 m wide x 2.3 m long x 2 m high. The surface area was replaced by a 1/4 inch thick aluminum plate. The plenum has dimensions of 0.8 m wide x 2.3 m long x 0.6 m high. About 45% of the secondary flow went through the slots on the surface area and the remainder entered the slots on the back wall behind the surface area.

Results

The fire source was represented by a polypropylene pool fire with pan diameter ranging from 4 in. to 12 in. Polypropylene can be ignited with a 100 watts heating source. The ignition was simulated with a 12 V battery and a diesel engine glow plug. The ignition typically took 15 - 30 seconds. The mass loss from the burning was monitored by a loadcell. After ignition, all polypropylene fires have a long period of slow growth (an incubation period) and then accelerate to steady state burning. A sample of mass loss history (for a 6 in. polypropylene pool fire) is given in Figure 1. For the 6 in. fire, the incubation period was about 25 minutes and the steady state burning rate was 6 kW.

Instrumentation included thermocouples, optical probes for measuring smoke density at various locations, a loadcell and an FTIR multiple gas analyzer. For the present study, polypropylene pool fires were placed either in the plenum or on the surface area of the wet bench. To examine the possibility of fire detection by gas sampling, the increases of concentration for CO and CO_2 due to a fire were measured at various locations in and around the wet bench when either a 4 in. or 8 in. polypropylene pool fire was placed in the plenum or on the surface area. The rise in CO concentration was too small

to be measured. The rise in CO_2 concentration was also negligible except in the exhaust duct. With a fire in plenum, the rise in CO_2 concentration was about 65 PPM for a 4 in. fire and 650 PPM for an 8 in. fire. With a fire on the surface area, the rise was approximately 44 PPM for a 4 in. fire and 400 PPM for an 8 in. fire.

For protection of the plenum, two nozzles were used (one on each end wall). The pool fire was placed in the middle with two nominal 7 in. cylinders on each side to block the direct impingement of water mist. Tests were carried out with various fire sizes and results are shown in Figure 2. The extinguishment time is less than 10 seconds for both 4 in. and 12 in. fires. It rises to above 10 seconds for 6, 8 and 10 in. fires. This suggests that there are at least two competing fire suppression mechanisms. The fine water spray system was also tested for surface area protection and the extinguishment time is less than 10 seconds.

References

1. Fisher, L.F., Williamson, R.B., Toms, G.L., and Crinnion, D.M., "Fire Protection of Flammable Work Stations in the Cleanroom Environment of a Microelectronic Fabrication Facility," Fire Technology, Vol. 22, NO.2, May 1986.

2. Wu, P.K., Chaffee, J., and Knaggs, B., "A Wet Bench Free-Burn Test Under FMRC Fire Products Collector," Technical Note, Factory Mutual Research Corporation, Norwood, MA, April 1995.

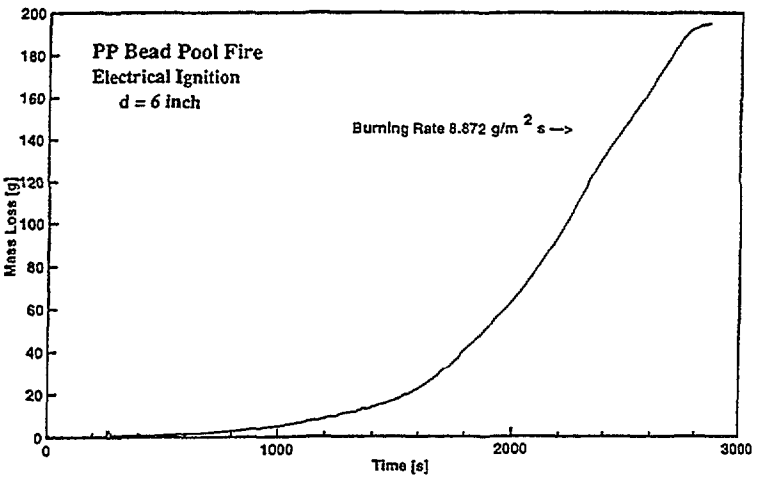

Figure 1. Mass Loss History of a 6 inch Polypropylene Pool Fire

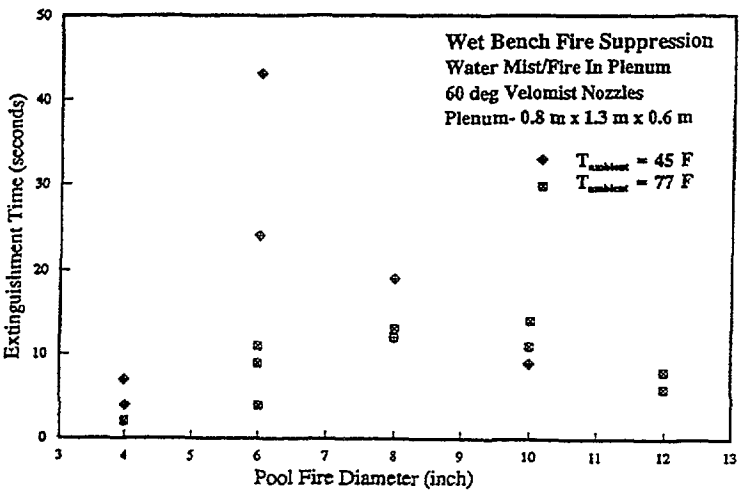

Figure 2. Extinguishment Time vs Pan Diameter For Plenum Fire Tests