PROTECTION OF SEMICONDUCTOR FABRICATION FACILITIES

INTRODUCTION

National Fire Protection Association (NFPA) documents describe a level of fire protection agreed on by persons representing a variety of interests. The guidance in these documents does not reflect unique conditions or special considerations, such as system performance under adverse conditions. Nor does NFPA guidance reflect the increased system reliability AXA XL Risk Consulting recommends for high valued properties.

This PRC Guideline takes a position on the provisions of NFPA 318 that AXA XL Risk Consulting believes require clarification or changes. To understand the position, this PRC Guideline must be read with a copy of NFPA 318. The provisions of the NFPA document are not repeated.

POSITION

General

Any room or area (zone) where the concentration of airborne particles is controlled to within specified limits falls under the scope of this standard. Controlled zones include areas below cleanroom floors, interstitial spaces, and all portions of the air stream. See PRC.17.11.0 for more information on cleanrooms.

Fire Protection

In addition to the automatic extinguishing systems recommended by NFPA 318, provide portable clean agent fire extinguishers in each cleanroom. Also consider providing fire hose stations either outside each cleanroom exit and/or on the floor below the cleanroom (sub-fab floor), if one exists.

Arrange fire protection systems so that no single impairment of water supplies or yard mains will take any sprinkler system out of service.

Provide a reliably water supply by providing two independent supplies. Two connections to the same public water supply only qualify if the supply is well gridded and the feeds are not between the same two sectional valves.

Automatic Sprinkler Systems

Install automatic sprinkler systems throughout buildings containing cleanrooms or clean areas, and design the systems to protect the cleanrooms from exposing building hazards.

Where one sprinkler riser feeds more than one cleanroom, or more than one section of a cleanroom, install separate control valves to limit the extent of protection impairments.

Install automatic sprinklers in the subfabs and under raised floors of cleanrooms, using the same design as the sprinklers in the cleanroom.

Protect gas storage rooms with a sprinkler design of 0.25 gpm/ft^2 (10.2 L/min/m^2) over the most remote 3,000 ft^2 (279 m^2).

Refer to PRC.8.1.0 for sprinkler requirements for flammable liquid storage areas.

Provide deluge water spray systems per applicable NFPA standards for bulk Silane gas systems.

Detection Systems

Install a high sensitivity, sampling type smoke detection system throughout the return airstream of the cleanroom in accordance with the requirements of NFPA 72. Include pick-up points near stockers and inside enclosures for such critical equipment as ion implant units and steppers.

Air Supply And Recirculation Systems

In addition to the components recommended in this section, use makeup air prefilters that meet the requirements for Class 1 filters in accordance with ANSI/UL 900.

Ductwork

Use metallic ducts wherever possible. If plastic ducts or plastic lined ducts are required, use those listed in the FM 4922 for use without sprinklers in cleanrooms. Do not install dampers or any other devices in fume exhaust ducts that could obstruct fume removal. In no case should an FM 4910 approved plastic alone be substituted or seen as equivalent to an FM 4922 approved duct.

Avoid duct penetrations through fire rated partitions as much as possible.

Arrange and protect plastic ducts in accordance with PRC.2.3.2, except provide sprinkler protection for ducts of 8 in. (20 cm) diameter or larger. Install sprinklers so that the frame arms are parallel to the duct.

Provide sprinkler protection for all ducts that convey flammable solvents. Provide sprinklers for all branch ductwork unless guidance in the following is provided:

- Where benches are of combustible construction and not protected, or where benches are constructed of materials tested to ANSI/UL 2360 (or equivalent), do not apply this section retroactively.
- In older fabs the sprinkler within close proximity of the transition piece may be the only unobstructed protection and automatic alarm for the combustible tool. Maintain a sprinkler head within 2 ft (0.6 m) of the transition piece regardless of duct size or construction.
- Do not use combustible equipment for high temperature processes or processes requiring flammable and combustible equipment.
- A fixed pipe CO2 fire suppression system in wet benches handling flammable gases or liquid or combustible liquids. The system design is in accordance with NFPA 12, with automatic actuation of the system with optical flame detection.
- When the CO2 system operates, automatically shut off power to the work station, but do not shut down the exhaust air handling system.
- Note: Water mist or alternate agent extinguishing systems are also acceptable in lieu of sprinklers or CO2.

Provide drainage wherever sprinklers are provided in ductwork.

HEPA And ULPA Filters

The requirement for HEPA and ULPA filters was changed from meeting ANSI/UL 586 to meeting a class I rating when tested in accordance with ANSI/UL 900. The flammability criteria used in the

ANSI/UL 900 test is almost as severe as that used in the ANSI/UL 586 test. Present cleanliness requirements are beyond the scope of quality of filtration tested in ANSI/UL 586. Either test is satisfactory for filters used in cleanrooms.

The exception to the filters section allows Class II filters under certain conditions. When tested in accordance with ANSI/UL 900, a Class I filter will not allow a flame front to pass beyond the filter. A filter can fail altogether and not receive any type of rating or can pass the Class II criteria. This Class II criteria allows the flame front to extend approximately 8 ft (2.4 m) past the filter to the end of the test duct. Some contractors providing proposals for cleanroom air handling systems have argued that the difference in cost between Class I and Class II filters of $100/ft^2 ($1075/m^2) is an unjustifiable expense. The response is that cleanroom values can be as high as $9000/ft^2 ($96,774/m^2) and an hour of downtime can be worth hundreds of thousands of dollars. Reducing a loss area by 1 ft^2 (0.09 m^2) or reducing downtime by 1 min would pay for hundreds of Class I filters. Other contractors argue Class I and Class II filters are not that different when loaded. In cleanroom applications there should not be enough loading to create an appreciable flame front. Loaded filters cannot be tolerated in cleanroom service. The industry likes to use the less expensive Class II filters for pre-filters, which are frequently changed. AXA XL Risk Consulting does not agree with the use of Class II filters in cleanroom installations.

FM approved filters and MIL-F-51068 filters are comparable to ANSI/UL 586 filters.

Cleanroom Smoke Exhaust System

Design air handling systems to automatically divert recirculated air to exhaust upon actuation of any smoke detector in the return air stream. Additional makeup air may be required to prevent unacceptable pressure differentials.

When air handling systems cannot be used for smoke removal, provide an independent smoke removal system designed to provide 7 cfm/ft^2 (2.1 m^3/min/m^2) of floor area near large combustible tools and 3 cfm/ft^2 (0.9 m^3/min/m^2) of floor area elsewhere. Distribute smoke exhaust points uniformly throughout the cleanroom and use as many as practical.

Locate makeup air intakes remote from smoke exhaust points. Install dampers in the air intake system and arrange them to close upon detection of smoke. Detect smoke with air sampling detectors. Verify that an alternate source of makeup air is adequate when air intake dampers are closed.

Use ductwork constructed of noncombustible material in smoke removal systems. Provide emergency switches for actuation of the smoke removal system in a constantly attended area such as a command center. Wire the smoke removal system from an independent power supply and fireproof all cables exposed to the area being served.

Construction

Cleanrooms

Locate cleanrooms in noncombustible buildings only. Separate cleanrooms exposed by combustible occupancies or other cleanrooms with walls of 2-hr fire resistance rating; 3-hr if the exposure is severe. Examples of severe exposures include a neighboring room with higher combustible loading than another cleanroom, a neighboring cleanroom with higher than normal combustible loading, any cleanroom with very expensive and easily contaminated equipment or any cleanroom likely to contain large amounts of expensive product. Protect door openings with single 3-hr rated fire doors.

Use noncombustible materials of construction for all cleanrooms and clean areas. Also, use noncombustible interior finish materials for wall, floor and ceiling applications. Prefabricated aluminum panels with aluminum honeycomb interior are preferred. Painted gypsum board or aluminum panels could also be acceptable. Do not use materials containing any plastics, including metal sandwich panels with non-rated plastic cores. Also do not use panels with paper cores.

Run necessary service water lines below the cleanroom floor and extend them into the cleanroom at the equipment. Provide leak detection equipment in areas where water lines exist and create a significant exposure to the cleanroom.

There is often a desire to use expanded plastic panels and/or an Exterior Insulation Finishing System (EIFS) for exterior wall construction. The excellent thermal insulation properties of the plastics make these systems appear ideal for wall systems of semiconductor fabrication buildings (FABS). Listed systems of this type are often treated as noncombustible. Care should be taken in evaluating these systems in construction of FABS. Do not expose these wall systems with gas houses, silane distribution centers, combustible yard storage, or similar hazards. Involvement of expanded plastic panels or EIFS can create large amounts of contaminating products of combustion. Since the make-up air systems could injest these contaminants and treatment would be beyond the capabilities of the filters, a seemingly harmless fire could shut down the entire cleanroom. Where these wall systems are necessary, consult PRC.2.0.2 for additional guidance.

Chemical Storage And Handling Rooms

Arrange and protect flammable liquid storage rooms in accordance with PRC.8.1.0.

Flammable And Combustible Liquid Delivery Systems

In addition to the recommendations in the code, also do the following:

- Locate the pump, bulk tank, piping and day tank in an area with secondary containment. Provide manual shutoffs at the bulk tank and at points of use.
- Arrange all chemical delivery systems to be fail-safe with manual reset only. Provide redundant liquid level and overtemperature sensors in series with the normal operating controls. When possible, provide backup power. Upon loss of power, high or low liquid level, or excess temperature, close chemical supply valves, open vents and turn off heat sources.
- Terminate day tank vents or the vents from their cabinets outside the building. Do not manifold vents or terminate them in ductwork. Provide secondary containment inside tank cabinets.
- Arrange chemical delivery systems to allow access for testing and maintenance.

Electrical Design

Determine hazardous zones in accordance with NFPA 497. Install electrical equipment in those areas in accordance with Article 500 of NFPA 70.

Provide emergency power for all fume exhaust systems and smoke removal systems.

Design heating systems and controls for electrically heated plastic tanks, plastic lined tanks and plastic tanks with noncombustible liners in accordance with PRC.9.5.1.