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Research Article

Indoor/Outdoor Airflow and Air Quality

Analyses of smoke management models in TFT-LCD cleanroom

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Abstract

This study evaluated the effectiveness and performance of smoke management models in a TFT-LCD cleanroom. Several smoke management models are discussed in a distinct 3-level cleanroom compartment. The tools used included a fire dynamics simulator (FDS) and SIMULEX. The design fires were 3 MW and 5.4 MW in ultra fast fire, respectively. In life safety, both a downward smoke exhaust system and upward smoke exhaust system, incorporating a decrease of filter fan unit air supply rate, could be used in a cleanroom, according to the simulation results of performance-based design. For occupant evacuation, the SIMULEX results showed a total evacuation time less than smoke layer descending time, which descended to 1.8 m height from floor to smoke layer in all FDS simulations. In view of property protection, insurance companies generally require significantly higher standards of property protection. For 3 MW or more heat release rate, smoke was hardly controlled by any smoke exhaust system in the cleanroom without sprinklers.

Keywords

smoke management models,
TFT-LCD cleanroom,
fire dynamics simulator (FDS),
SIMULEX,
smoke exhaust system

Article History

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1 Introduction

The unique 3-level cleanroom includes a supply air chamber (SAC), fabrication (FAB), and return air plenum (RAP), such as thin film transistor-liquid crystal display (TFT-LCD) and light emitting diode (LED). Therefore, these industries have given tremendous attention and efforts to develop an advanced loss prevention strategy to reduce the risk of fire.

Some special features of TFT-LCD cleanroom now used in high-tech plants include the following:

(1) There are numerous toxic and explosive chemicals being manufactured, processed, and stored. Most of these chemicals are so active that they can readily cause fires or other severe damage in the event of accidental leakage.

(2) The flow field in a cleanroom differs from that in other buildings. The conditioned airflow is drawn downwards vertically from the filter fan unit (FFU) to the FAB area, through the perforated raised floor, and eventually to the sub-FAB area.

(3) Process tools inside the cleanroom are highly sensitive to contamination from smoke/particulates and water.

(4) The zone area of a cleanroom for such plants is very large, but the occupant density is low due to highly elaborate automation. Moreover, the distribution of production lines has become increasingly complicated owing to space limitations. Therefore, occupant evacuation plans become extremely important and may alter occasionally due to the retrofit and renovation of facilities.

Acorn (1993), in an intensive review entitled "Code Compliance for Advanced Technology Facilities", described and discussed the various code requirements for advanced facilities in terms of hazardous production material (HPM) storage, mechanical venting, air-conditioning systems, fire suppression, electrical power, and evacuation alarm systems.

Heskestad and Lutton (1997) experimentally investigated the reduced scale cleanroom fire (the room size is 4.8 m × 6.0 m × 2.44 m in height). Specifically, Heskestad and Lutton measured ceiling temperature when using a CH_4 burner (600 kW) to simulate cleanroom fire. Cheng et al. (1998) applied the commercial code of STAR-CD to study

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