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Justifying Excess Travel Distance in a Megafactory with Fire & Egress Modeling Rational Analysis

How Summit Fire Consulting helped prove that the proposed design of a global manufacturer's megafactory met the intent of the code despite its travel distance surpassing the prescriptive requirements.

According to the International Building Code (IBC), warehouses are only allowed 450 feet of travel distance when they include a sprinkler system. When a global vehicle manufacturer discovered their proposed megafactory design exceeded the IBC limitation, they turned to Summit Fire Consulting for help.

Summit Fire Consulting (SFC) helped a global vehicle manufacturer prove that extended travel distances in their proposed megafactory did not present a lower level of safety or subject occupants in certain areas of the factory to conditions that may hinder their ability to self-evacuate. SFC's comprehensive and detailed fire and egress modeling analysis helped the client save a significant amount of money and design time.

ABOUT GLOBAL VEHICLE MANUFACTURER

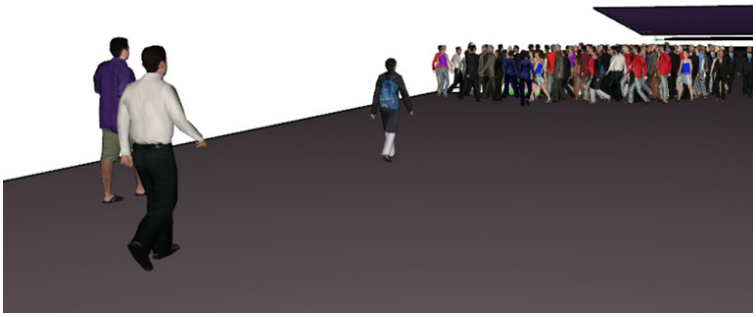
The vehicle manufacturer's megafactory is an industrial warehouse that fabricates, stores, and manufactures vehicles throughout its facility spanning several millions of square feet. Due to the size of the building, prescriptive egress distances are challenging to maintain.

PROBLEM

The vehicle manufacturer wanted design flexibility when planning its new industrial warehouse. The large floor areas required by the operation resulted in a need for longer than prescriptively allowed travel distances throughout several locations of the facility. One of the biggest was the assembly portion of the facility, which included four levels

atmospherically connected to one another. It also included several areas with a lower vertical height than most typical warehouses and a greater amount of horizontal area, so smoke spread in the event of a fire would be unconfined.

Travel distance in this context refers to the maximum distance that a building occupant may have to travel from any point within a building to reach the nearest exit. The longer travel distances impacted the time egress, which was the amount of time it took for occupants to safely evacuate the building during a fire emergency.



Egress Model

The vehicle manufacturer considered three potential paths to code compliance in order to resolve the travel distance issue:

1. *Design a smaller facility provided with exits within the prescriptively allowed distance.*
2. *Compartmentalize the warehouse and add horizontal exits.*
3. *Provide a performance-based design alternative supported by fire and egress modeling that showed the originally proposed design did not hinder the occupants' ability to evacuate the building.*

Designing a smaller facility was not feasible based on the manufacturer's functional objectives for the facility; compartmentalizing the building would have been logistically challenging for the assembly line to pass through a fire-rated wall, not to mention the cost implications.

SOLUTION

Not wanting to alter the design of the megafactory, the vehicle manufacturer turned to Summit Fire Consulting for a thorough fire and egress modeling analysis. Specifically, the analysis would evaluate the suitability of extended travel distances throughout the facility.

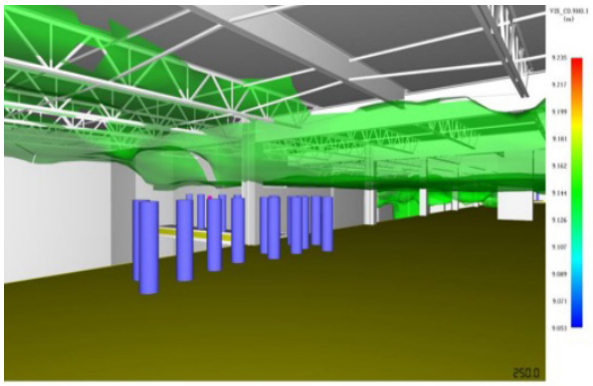
SFC began the process by writing a Design Brief, including how they would perform the fire and egress modeling. The Design Brief is a critical step in the performance-based design process serving to establish key performance criteria such as tenability thresholds for temperature, visibility and carbon monoxide, as well as fire characteristics such as growth rate, soot yield, and peak heat release rates (HRR). Establishing these key performance criteria in the Design Brief allows for various stakeholders to comment and provide feedback prior to running computationally demanding fire and egress modeling iterations.

To better understand the situation, SFC fire protection engineers sat down with the vehicle manufacturer and local fire marshal, in person. That allowed the team to address the fire marshal's concerns and walk through the approach. Once all apprehensions were resolved, SFC began the analysis.

The fire protection engineers used two tools to model all inputs and justifications they included in their Design Brief:

1) Fire Dynamics Simulator (FDS): ***A computer program that uses computational fluid dynamics (CFD) techniques to simulate the behavior of fires.***

FDS can model the spread of smoke and its impact on tenability throughout a face in different environments by taking into account various factors such as the geometry of the space, the properties of the fuel and ventilation, and the effects of temperature, pressure, and flow. Through the documentation

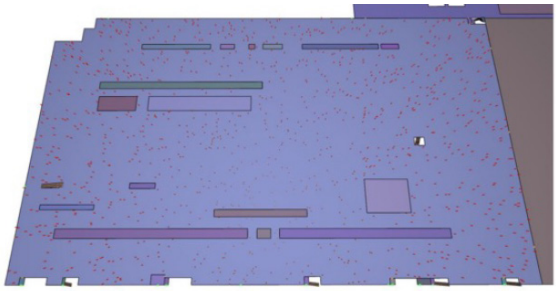


Fire Scenario 3 Visibility Iso-Surface (9 meter threshold) at t=250 seconds

and approval of the Design Brief, various fire scenarios were established that will then be modeled in order to understand expected tenability conditions throughout the facility in the event of a fire.

In accordance with NFPA 92, the utilization of a CFD model is an approved design approach for smoke movement and smoke control modeling, including the smoke-fill approach, and is not considered an alternate means or method.

2) Pathfinder: ***An egress simulator that uses 3D modeling techniques to simulate the layout of a building, the location of exits and obstacles, and the behavior of people during an emergency.***



Egress Model Geometry and Occupant Starting Positions

It takes into account factors such as the density of people, their walking speeds, and their decision-making processes, and it can simulate multiple scenarios to evaluate the effectiveness of different evacuation strategies.

SFC modeled different types of large fires involving Group A plastics, rack storage, pallet loads and vehicles. They also examined how each fire scenario impacted an occupant's ability to evacuate.

Was there adequate time for occupants to exit safely? Based on the modeling, the answer was yes.

Many fire scenarios were evaluated; most yielded favorable results, however, one fire scenario, which was located close to the mezzanine, proved to be a challenge and required some additional life safety measures to be implemented. The occupants within this area would be extremely intimate with the smoke and fire conditions. SFC discussed this issue with the vehicle manufacturer and came up with a solution: draft curtains. These are small curtains consisting of several feet of fabric or solid material that hang from the ceiling to slow down smoke and prevent it from spreading. In other locations, glass and other partition walls were utilized to prevent the migration of smoke to certain areas.

Draft curtains allowed SFC to demonstrate tenability in several key areas of the facility. So, even though the megafactory design exceeded the prescriptive code's travel distance requirements by over 100 feet, the analysis proved that occupants were able to exit the building before untenable conditions occurred. That's where the time egress (RSET vs. ASET) came into play.

RSET vs. ASET

Required Safe Egress Time (RSET) and Available Safe Egress Time (ASET) are used to evaluate whether or not there is sufficient time for occupants to evacuate a building during a fire.

RSET is the minimum amount of time required for all occupants to safely evacuate a building, or a portion thereof, during a fire. It takes into account factors such as the size and complexity of the building, the number of occupants, the location of fire exits and the fire protection systems in place. The Pathfinder egress model provides this information.

ASET is the amount of time available for occupants to evacuate a building before they are exposed to harmful levels of heat, smoke or toxic gases.

It considers the fire size, fire growth rate, and the effectiveness of the fire protection systems in place. The FDS model provides this information.

The goal of fire protection engineering is to ensure that RSET is less than or equal to ASET, which means that there is enough time for all occupants to safely evacuate the building in the event of a fire.

In the megafactory's case, the FDS and Pathfinder simulations provided the ASET and RSET, respectively, which were compared to draw conclusions about the suitability of extended travel distances within.

RESULTS

Summit Fire Consulting performed a fire and egress modeling analysis to determine the ASET and compare it with the RSET throughout the manufacturing facility. After modeling severe case fire events, the finding showed that each floor provided tenable conditions long enough for safe egress. The ASET was greater than the RSET for each scenario for each floor level.

RSET vs ASET Conclusions

Level	Fire 1 RSET	Fire 1 ASET	Fire 2 RSET	Fire 2 ASET	Fire 3 RSET	Fire 3 ASET	Fire 4 RSET	Fire 4 ASET
Level 1	390	>600	390	>600	-	-	-	-
Mezzanine 2	215	350	215	400	-	-	-	-
Level 2	286	>600	286	>600	286	>600	286	>600
Mezzanine 2	290	>600	290	>600	290	>600	342	500

The team delivered these findings in a clear and concise report with visual aids and numerical graph data to the vehicle manufacturer and the fire marshal serving as the authority having jurisdiction (AHJ).

The large volume within the facility provided a significant smoke collection reservoir that allowed occupants an opportunity to safely exit before untenable egress conditions developed.

As a result, SFC concluded that extended travel distances, up to and including 550 feet (22% increase over prescriptive code), did not present a lower level of safety or subject occupants in any area of the facility to conditions that could hinder their ability to self-evacuate.

BOTTOM LINE

The global vehicle manufacturer was able to prove its proposed design met the underlying life safety objectives of the prescriptive code despite exceeding the specified maximum travel distance. This meant it could keep its open layout, which optimized efficiency for its internal production needs. The analysis could also be easily adapted if the building went through any additional design phases.

In the end, Summit Fire Consulting saved the vehicle manufacturer significant time and expense.

ABOUT SUMMIT FIRE CONSULTING

Summit Fire Consulting is a team of licensed fire protection engineers and code consultants partnering with owners, architects, and developers to solve complex code challenges, accelerate approvals, and unlock designs others say can't be built.

In addition to timed-egress evaluations, Summit Fire Consulting has experience with modeling structural fire resistance, sprinkler detection times, smoke detector spacing, device activation times and smoke and heat venting.

Going beyond compliance, Summit Fire Consulting designs safer, more efficient buildings that maximize long-term value. Backed by the strength of the full Summit Companies network, our team delivers responsive, code-aligned solutions wherever your project takes you.

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