Failure Modes and Effects Analysis (FMEA)— Fire Alarm System

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The purpose of the Fire Alarm System is to provide occupants of high-rises with a means of recognizing, transmitting, detecting and suppressing fire emergencies. The system consists of both human and mechanical components designed to ensure life safety and limited destruction of property.

New York City codes require that all class "E" high-rises have a communications system (fire command station) and a personnel program to address fire emergencies. In addition to personnel, the system comprises of alarm transmitting, fire detecting and fire suppressing functions to achieve the desired aforementioned purpose.

The human components of the system include the fire safety director, who directs the evacuation from the fire command station; the fire wardens, who oversee the evacuation from the fire floor and the floor above the fire floor; the male and female searchers search for colleagues on the affected floors and direct them to the safest emergency stairwells; the fire brigade responds to certain areas and assist in the evacuation; and finally, the occupants and the visitors complete the human components of the system.

The mechanical components help relay audio/visual information to the occupants, and activate fire detecting and suppressing activities. The components include the fire command station, smoke and heat detectors, duct smoke detectors, strobe light signals, audio alarm, manual pull stations, warden phones, fail-safe door release, dampers, elevator recall, purge controls, fire extinguishers and sprinklers.

FMEA will be instituted for each of these components of the fire safety system. Any of the failure modes described herein can have a significant and devastating effect on fire emergency evacuations and life safety. Fire codes in New York City are very stringent and FDNY inspections are conducted regularly to ensure that building owners and managers are in compliance with the fire codes.

Failure Modes and Effects Analysis (FMEA)

Fire Alarm System in a Class "E" High-Rise Building in New York City/Human and Mechanical Components

Human Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Fire Safety Director (FSD)	FSD is not present when fire alarm activates	In a meeting in another building	No announcements to fire floor and floor above the fire floor Confusion amongst occupants as to what is happening on their floor	High	Hire a Deputy FSD to cover for FSD absences
	FSD not intelligible when fire alarm activates	Foreign-born-speaks with unintelligible accent	Announcements cannot be understood by tenants Confusion amongst occupants as to what is being said over the PAS	High	Register FSD in linguistics school to further develop clarity when speaking Terminate FSD
	FSD is not familiar with Fire Command Station (FCS)	Lack of training	Errors could lead to announcements not getting through to tenants Confusion amongst occupants as to what is happening on their floor	High	Schedule weekly FSD training sessions on Saturdays (off hours) Terminate FSD
	FSD in building, but not at FCS	Personal break	No announcements to fire floor and floor above the fire floor	High	Hire a Deputy FSD to cover for FSD absences Install an auxiliary tone to summon FSD to FCS

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Human Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Fire Warden (FW)	FW is not present when fire alarm activates	Absent from work	No communication with FSD from fire floor and floor above Occupants looking for directions from FW that are not forthcoming FSD does not receive situation awareness	Moderate	Train other people as Deputy FWs Tenants to call FSD when FW is absent and assign someone else
	FW is not familiar with duties	Lack of training Disinterested Nervousness	No communication with FSD from fire floor and floor above Occupants looking for directions from FW that are not forthcoming FSD does not receive situation awareness	Moderate	Schedule a training session on duties and floor familiarization Reassign FW duties
	FW cannot perform functions	Death from exposure to smoke	No communication with FSD from fire floor and floor above Occupants looking for directions from FW that are not forthcoming FSD does not receive situation awareness	Moderate	Deputy FW takes over the evacuation On-the-spot assignment of FW duties to untrained "leader"

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Human Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Searchers (SE)	SEs are not present when fire alarm activates	Absent from work	No sweep of the fire floor in search of occupants Failure to direct and guide occupants to safe emergency stairwells Confusion amongst occupants who don't know location of emergency stairwells	Moderate	Train other people as SEs Tenants to call FSD when SEs are absent Post additional universal visual directional signs
	SE is not familiar with duties	Lack of training Disinterested Nervousness	Evacuation is compromised Occupants looking for directions from SEs that are not forthcoming	Moderate	Schedule a training session on duties, compartmentalization of offices and emergency stairwell familiarization Reassign SE duties
	SE cannot perform functions	Death from exposure to smoke	Evacuation is compromised	Moderate	Train other people as SEs for greater probability that a SE will be present during a fire alarm On-the-spot assignment of SE duties to untrained "leader"

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Fire Brigade (FB)	One FB member not present when fire alarm activates	Out to lunch	A FB post will not be covered	Moderate	Assign a security officer to FB functions Assign an engineer to fire brigade functions
	FSD not present when fire alarm activates	FSD not in building	FB has no direction as to where to report to FB reports to wrong locations	Moderate	Hire and train a Deputy FSD to cover for FSD absences
	Entire FB not present when fire alarm activates	Unionized labor strike	Guidance and assistance in evacuations compromised	High	Reassign FB duties and train a temporary FB staff
	FB has no portable radio communication with FSD	No radios available	Evacuation is compromised due to failure to communicate situation awareness to FSD	High	Purchase portable radios for all FB members
Building Engineer (BE)	BE is not present when fire alarm activates	In a meeting in another building Out to lunch In an unaffected floor	No one available whose familiar with building management systems (BMS) to advise the fire department Mechanical and electrical systems continue to operate when they should be shut down Fire department fire suppression activities compromised Occupants' life safety compromised	High	Hire a Deputy BE to cover for BE's absences Train Deputy FSDs in basic building management systems as back-up to BE Provide portable radio for emergency communications

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Human Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Occupants	Do not react to initial fire alarm	Complacency No history of fires in high-rise	Not efficient time to evacuate Compromise evacuation Death	High	Change human behavior and misperceptions about fire emergencies though training Increase number of annual fire drills to inculcate in occupants the importance of fire alarms
	Unable to descend the emergency stairs unassisted	Physical, sensory or cognitive disability	Evacuation compromised Injury Death	High	Design a "buddy" system and train "buddy" on use of rescue chairs Permanently post rescue chairs on floor where occupants with disabilities work
Visitors (temporary occupants)	Follow directions from untrained host and not the FSD or FW	Unfamiliarity with floor, building layout, fire alarm response procedures and emergency stairwell locations Dependent on advise of untrained host	Not efficient time to evacuate Evacuation compromised Death	High	Provide guests with fire alarm information cards upon registering at the lobby desk Train all new employees (hosts) on fire alarm response and evacuation procedures
	Unable to descend the emergency stairs unassisted	Physical, sensory or cognitive disability	Evacuation compromised Injury Death	High	Design a "visitor buddy" system and train "buddy" on use of rescue chairs Temporarily post rescue chairs on floor where visitor is situated

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Mechanical Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Fire Command Station (FCS)	FCS destroyed	Electrical malfunction Blackout	No announcements to fire floor and floor above the fire floor FSD does not know of a fire in progress No fire situation awareness data for fire department upon arrival	High	Install a secondary FCS in a fire protected room Institute annual quality assurance inspection of FCS and related areas Connect FCS to generator
Smoke Detector (SD)	Fails to detect smoke in timely fashion Fails to detect smoke altogether	Calibration not properly set Wire disconnected Addressable point disconnected by technician	Smoke goes undetected Confusion amongst occupants as to why there is no alarm activation Fire evacuation delayed and compromised	High	Institute periodic calibration test by vendor Replace old smoke detectors/modules Maintenance on the off-hours only
Heat Detector (HD)	Fails to detect heat in timely fashion Fails to detect heat altogether	Calibration not properly set Wire disconnected Addressable point disabled by technician	Heat goes undetected Confusion amongst occupants as to why there is no alarm activation Fire evacuation delayed and compromised	High	Institute periodic calibration test by vendor Reset to lower point of activation Maintenance on the off-hours only

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Mechanical Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Duct Smoke Detector (DSD)	Fails to detect smoke in a timely fashion Fails to detect smoke altogether	Failure to install DSDs Calibration not properly set Addressable point disabled by technician	Smoke will travel undiscovered to other parts of the high-rise Number of people in danger of smoke inhalation increases substantially Evacuation of additional floors not originally affected by the fire Death	High	Install DSDs throughout the HVAC system Reset calibration Maintenance on the off-hours only
Strobe Light Signal (SLS)	No SLS activation	Wire cut Bulb burnt Disabled by technician	Deaf or hearing impaired occupants will not see fire emergency signal Evacuation compromised	Moderate	Institute annual quality assurance inspection of FCS and related areas Weekly check of SLSs to ensure they are functioning properly Have in stock SLSs to immediately replace malfunctioning SLSs Maintenance on the off-hours only Do not hire hearing impaired/deaf people (violation of ADA)

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Mechanical Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Audio Fire Alarm (AFA)	Fire alarm not heard on fire floor and fire above fire floor	Electrical malfunction Mechanical malfunction Action disabled at FCS	No one knows of a fire emergency unless witnessed. Confusion amongst occupants as to why there is no audio fire alarm activation Fire evacuation delayed and compromised	High	Have electricians inspect wiring Indicate in the fire alarm log when the action is disabled. Only disable actions when building is closed for business
Manual Pull Station (MPS)	Fire alarm does not activate Addressable point disabled by vendor Unable to locate a MPS	Addressable point disabled Physically damage to MPS-unable to activate alarm	Confusion amongst occupants as to why MPS does not activate the fire alarm FSD unaware of fire condition-does not make an announcement Fire evacuation delayed and compromised	High	Inspect MPSs daily for physical damage Only disable when building is closed for business Post signs indicating locations of MPSs
Warden Phone (WP)	No communication Static Low volume	Ground fault Wire disconnected "Open" phones throughout property	No communication with FCS No situation awareness communicated to FSD FSD cannot confirm if evacuation is in progress and stairwell being used FSD cannot confirm if all occupants have evacuated	High	Inspect and test the FWPs daily Inform vendor to correct all issues with FWPs

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Mechanical Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Fail-Safe Door Release (FSDR)	Locks do not release	FCS malfunction No electrical power Action disabled	Cannot enter reentry floors Office space path of egress compromised	High	Test FSR daily Inspect all locking mechanisms Ensure action is not disabled at FCS
Dampers and fans	Dampers remain open Fans continue to run	FCS malfunction Closing mechanism not operational	Smoke travels uninterrupted to other areas of building Evacuation of additional floors not originally affected by the fire	High	Test dampers and fans on a set schedule Inspect all closing mechanisms on the dampers
Elevator Recall (ER)	Elevators serving the fire floor fail to recall	Programming error	Elevator occupants might be exposed to fire floor as elevators continue to run normal Elevators unavailable for fire department personnel on street floor Fire suppression activities delayed	High	Elevator mechanic present in building Schedule weekly ER tests Review computerized program for errors
Fire Extinguishers (FE)	Unable to use	No adequately pressurized Missing Water fire extinguisher	Small contained fire spreads Unable to extinguish electrical fires	Moderate	Daily inspection by fire guards for pressure and existence Have FEs in stock to replace unusable FEs Change all FEs to chemical-based

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Mechanical Components	Failure Mode	Cause of Failure	Consequences	Predicted Severity	Recommended Solutions
Sprinklers	No water in pipes	Water drained due to construction work Frozen water in pipes	Occupant safety compromised Extensive property damage Death to occupants	High	Do not drain sprinkler when occupants are on floor Install heaters in cold areas to avoid freezing Install dry system to avoid freezing