

\$15 million Sight and Sound Theater Fire, Lancaster County Pennsylvania, 1997.

This report refers to a fire described in a report of the United States Fire Administration. This report can be found at <http://www.usfa.fema.gov/techreps/> . From this report , the following overview was copied, because it gives the main key issues that resulted in the catastrophic fire.

A FRAME calculation was made to check the validity of the method and the consistency of FRAME with expert knowledge. To show the consistency of FRAME with the expert remarks, a column with references to the calculation is given in the table. The FRAME generated report is shown further on.

Overview

On the morning of January 28, 1997, in the Lancaster County , Pennsylvania township of Strasburg, a fire caused the collapse of the state-of-the-art, seven year old Sight and Sound Theater and resulted in structural damage to most of the connecting buildings. The theater was a total loss, valued at over \$15 million.

The stage area was undergoing renovation and the theater was closed to the public, however, approximately 200 people, construction staff and employees were in the building at the time the fire started. Although the theater was built to conform to a two hour, fire rated assembly code requirement, many other fire protection features that could have assisted in saving the structure and reducing the damage were not present.

Further contributing to the resultant loss, was the failure of the alarm system to notify the fire dispatch communications center and the lack of an adequate, readily available water supply. The volunteer fire departments that responded were faced with difficult fire conditions and tactical challenges for which they had not been adequately trained, and were without the benefit of adequate pre-planning. Local fire service suggestions for built-in fire suppression and smoke ventilation systems during the pre-construction plan review phase were ignored.

While the incident was influenced by many conditions and situations which contributed to the large fire loss, fortunately there was no loss of life and only six minor injuries to the construction company staff. If the 1,400 seat capacity auditorium had been full, the situation could have been catastrophic.

The lessons learned as a result of this fire and collapse are similar to observations from comparable incidents in recent history. The Wolftrap Farm Theater and Pavilion fire in Fairfax County Virginia in 1988 suffered a total loss in the stage, props, dressing rooms and storage area. The pre-construction recommendation for a fire sprinkler system had not been heeded. When the facility was rebuilt, it was totally sprinkled.

The McCormick Place exhibition hall fire in Chicago, Illinois in 1967 was a public assembly occupancy built with fire protected steel construction and no sprinkler system.

Fortunately the fire started in the early morning hours; the possibility of life loss would have been staggering had the fire occurred during the day. This fast burning, high rate of heat production fire caused complete collapse of the building. The fire was discovered early but the alarm was delayed while maintenance personnel tried to control the fire. The new (rebuilt) McCormick place has a hydraulically calculated sprinkler system, smoke venting system in addition to one hour rated fire resistance protection on structural steel. The lessons learned here are not new. These examples are similar in situation and outcome to the Sight and Sound theater fire.

summary of key issues

issues	comments	FRAME
Fire origin	Welding operations caused the fire.	added as risk factor in the activation factor a
Sprinkler System Waived	The requirement for sprinklers in the high hazard storage area under the stage was offset for a central alarmed smoke detector system and 2-hour fire walls.	see special protection factor S =1.80 , calculation of initial risk R0 also indicates the need for sprinkler protection
Alarm System Failure	The alarm system failed to notify the county fire communications center and contributed to a delayed response.	Thermal detection included in special protection S and escape factor U
Employees Delayed Report of Fire	The fire was discovered by theater employees who used fire extinguishers for several minutes calling 911.	intervention time estimated at 15 minutes,
Structural Failure	Construction on the stage floor damaged the sprayed-on fire-resistant coating of steel structural members. The rapid fire spread caused early structural failure of the stage floor and contributed to fire extension	not included in the calculation, fire resistance assumed adequate
Water Supply Eliminated	The water supply pond originally intended to provide water for fire suppression was eliminated to accommodate the addition of a prop manufacturing building.	This situation causes a very low value for the water supply factor W
Lack of Compartmentalization	Several additions to the original theater connected the main structure to the maintenance buildings. The additional construction increased the overall size of the complex and compromised the compartmentalization. The high hazard storage area was not discretely separated from the rest of the structure.	Size of building gives area factor g
Lack for Exterior Fire Stream Access	Lack of windows prevented exterior fire streams from being effective until the roof collapsed.	this aspect results in a severity increase by the value of the ventilation factor v
Inadequate Staff	The theater staff and the fire department	lack of training in normal protection

Training	had not trained together on managing a fire emergency in this technically and tactically challenging complex facility	N
Pre-Fire Planning	The fire department was not familiar with the new additions and the increased potential risk to firefighter safety.	not included in FRAME
Fire Department Tactical operations	The initial fire attack was conducted with under-sized handlines, inadequate for the heavy fuel load in the building	not included in FRAME
Lack of Local Fire Code	There was no mandate for local government, fire officials, and local building owners to coordinate to ensure fire safe occupancies.	not included in FRAME

FRAME Approach

According to FRAME the following improvements would be required:

- sprinkler protection with adequate water supply and outside fire loop with hydrants
- smoke venting system for the room
- eliminating the high combustible material from the main compartment

The FRAME generated report for the existing situation is given below:

F.R.A.M.E. calculation report

The calculation is made for: Sight_and_Sound_Theater

location: Strasburg_Pennsylvania

The compartment is: main

The occupancy or use is: theater

Date of the calculation: 1997.08.01

Version: US_fire_administration

CALCULATION of the POTENTIAL RISKS

Data of the compartment :

The fire load 'immobile' Q_i is (in MJ/m²) : 100.00

The fire load 'mobile' Q_m is (in MJ/m²) : 1500.00

This gives for the fire load factor q : 1.59

The temperature rise T in °C is: 200.00

The average dimension m (in meters) is: 0.30

The combustibility class, M is: 3.00

This gives for fire spread factor i: 1.15

The theoretical length l is: 60.96 meter

The equivalent width b is: 60.96 meter

This gives for the area factor g: 1.83

The level number E is: 0.00

This gives for the level factor e: 1.00

The ceiling height h is: 12.19 meter

The flow of the ventilation system is (in Nm³/h): 0.00

The aerodynamic surface of the smoke vents is (in m²): 0.00 m²

The surface of the windows in the roof and upper third of the walls is: 0.00 m²

The smoke venting ratio is: 0.00

This gives for the venting factor v: 1.16

The height difference with the access level is: 0.00 meter

The number of access directions is: 3.00

This gives for access factor z: 1.05

These data give the following results:

The potential risk P for property is: 4.06

The potential risk P1 for the persons is: 2.22

The potential risk P2 for the activities is: 2.56

CALCULATION of the ACCEPTANCE LEVELS

The following elements determine the possibility of starting a fire:

Main activity: Non industrial activities

Heating systems: Heat transfer through water, steam, or solids ; Heat generator in a fire separated room

Energy source: electricity, coal, fuel oil

Electrical installations: In compliance with the rules and regularly checked

Explosion hazards: No explosion hazard

Secondary activities : Secondary welding operations

This gives for the activation factor a : 0.10

The following elements interfere with the evacuation of the compartment:

The number of persons to evacuate is: 1500.00

The number of exit units is: 29.00

The number of exit paths is: 2.00

The mobility factor p is defined as follows: mobile but dependent persons, there is a danger for panic

This gives for evacuation time factor t : 0.36

The following elements define the value of the content:

Replacement factor c_1 is: 0.00

The value of the content is estimated at: 15.00 Million US\$

with an inflation correction for 2000 of : 1.00

This gives for content factor c : 0.04

The environment factor r is defined with Q_i and M and is: 0.50

The dependency factor d is: 0.30

These data give the following results:

The acceptance level A for the property is: 1.10

The acceptance level A1 for the persons is: 0.64

The acceptance level A2 for the activities is: 1.16

THE ORIENTATION VALUE R_o , The Initial Risk :

The fire resistance of the structure is: 120.00

This gives with the calculated values of P and A , an orientation value R_o of: 1.80

CALCULATION of the PROTECTION LEVELS

The following elements define the value of the water supplies:

Type of storage: Water storage for general use, automatically filled; The available quantity is adequate

Distribution network: none

This gives for factor W : 0.54

The following elements define the value of the normal protection :

Notification: All the elements of the notification chain are present

Manual extinguishment means: Extinguishers adequate, Hose stations adequate

Arrival time for the fire brigade: Arrival after 10 to 15 min.

Training of people: Only a limited number of persons trained

This gives for factor N: 0.81

The following elements define the value of the special protection :

Type of automatic detection:

Automatic detection by thermal (heat) detectors , with electronic supervision of the system

type of fire brigade: Small permanent team + volunteer public fire brigade

This gives for factor S: 1.80

This factor S and the following elements define the value of the fire resistance :

The fire resistance of the structure is: 120.00

The fire resistance of the exterior walls is: 60.00

The fire resistance of the ceiling or roof is: 60.00

The fire resistance of the internal walls is: 0.00

This gives for factor F : 1.73

The following elements define the value of the escape possibilities:

Detection and signalisation: Automatic detection by thermal (heat) detectors , with electronic supervision of the system

Saveguarding of exit paths: Complete evacuation plan with adequate signalling

Protection by: Small permanent team + volunteer public fire brigade

This gives for factor U : 2.08

The following elements define the value of the salvage factor :

Protection and organisation: repairs possible with minimal help

This gives for factor Y : 1.00

These data give the following results:

The protection level D for the property is: 1.37

The protection level D1 for the persons is: 1.69

The protection level D2 for the activities is: 0.79

The calculated risk R is for the property: 2.70

The calculated risk R1 is for the persons: 2.04

The calculated risk R2 is for the activities: 2.79

These values are far away from the $R=1$ goal set by FRAME. The conclusion drawn by using FRAME can only be that the building was poorly protected for property, people and business.

It might be seen as pure luck that the fire started when there was no public in the theater, otherwise the FRAME risk values indicate that it would have resulted in several victims.