CBSpk
Congresso Brasileiro de Sprinklers
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Evolution of Storage Sprinkler Designs

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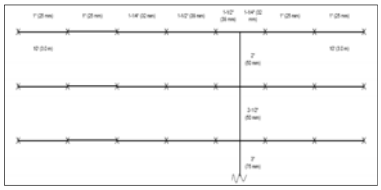
Fire Protection Circa Early 1900's

Sprinkler Design: Pipe Schedule

Pipe schedule was categorized based on occupancy hazard as either:

- Light Hazard
- Ordinary Hazard
- Extra Hazard



Fire Protection Circa 1940-1950

Changes in Industrial Practices

- Steel construction for buildings (collapse)

Fire Protection Circa 1940-1950

Changes in Industrial Practices

- Invention of forklift truck and storage racks constructed of steel (higher storage)

Fire Protection Circa 1940-1950

Changes in Industrial Practices

- Change from wood, metal and glass materials to plastic materials (much higher heat release fires)

Fire Protection Circa 1940-1950

Warehouse Fires With Pipe Schedule Sprinkler Systems

Fire Protection Circa 1950's


HANDBOOK OF
INDUSTRIAL
LOSS PREVENTION

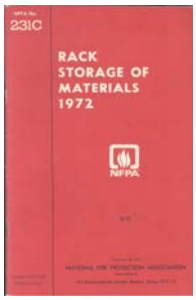
Density / Demand Area Design Concept Introduced

Fire Protection Circa 1960's

Fire Protection Consortium for NFPA 231C

From December 2, 1968 thru March 8, 1971, 25 ceiling-only sprinkler tests were conducted to determine protection designs for Class 1 thru 4 commodities in storage racks.

All but one test was conducted with K80 (K5.6) upright sprinklers.



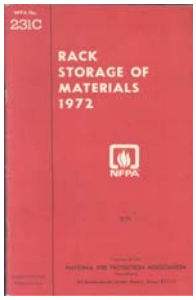
Fire Protection Circa 1960's

Fire Protection Consortium for NFPA 231C

What do you think the percentage of tests with demand areas ≥ 280 m² (3,000 ft²) is? 72%

What do you think the average demand area size is based on the 25 tests? 490 m² (5,285 ft²)

It would appear that K80 (K5.6) sprinklers do not protect storage very well



Fire Protection Circa 1970's

The K160 (K11.2) "Large-Drop" Sprinkler, the first sprinkler specifically designed to protect storage. Became known as a Control Mode Specific Application (CMSA) sprinkler

Also introduced the design concept of No. of AS @ Min. Pressure

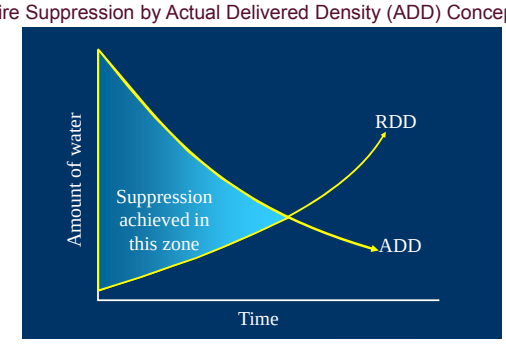
Fire Protection Circa 1970's

"Residential" sprinkler concept:

Led to development of Quick-Response thermal element

Fire Protection Circa 1980's

Fire Suppression by Actual Delivered Density (ADD) Concept



Fire Protection Circa 1980's

Evolution of sprinkler deflector design for pendent sprinklers

K80 (K5.6) Standard Spray Sprinkler

Fire Protection Circa 1980's

Evolution of sprinkler deflector design for pendent sprinklers

K200 (K14.0) Suppression Mode Sprinkler

Fire Protection Circa 1990 - 2014

Let's look at some test results to see what we can learn from them regarding:

- Density (i.e. Design Pressure Change)
- CMDA vs. CMSA Sprinklers
- Sprinkler Attributes (Characteristics)
- Assumed Performance

Fire Protection Circa 1990 - 2014

Density (Change in Design Pressure):

Density allows change in sprinkler design pressure as sprinkler spacing changes. The following test demonstrates the concerns with this design format:

- Commodity: CUP
- Storage Height: 6 m (20 ft)
- Ceiling Height: 9 m (30 ft)
- Storage Arrangement: Palletized
- Sprinkler K-Factor: K160 (K11.2) Upright
- Sprinkler Temperature Rating: 140˚C (280˚F)
- Sprinkler Density: 24 mm/min (0.60 gpm/ft²)

Fire Protection Circa 1990 - 2014

Density (Change in Design Pressure):

In the first test, the sprinkler spacing was 3.0 x 3.0 m (10 x 10 ft) for a sprinkler design pressure of 1.9 bar (27 psi)

In the second test, the sprinkler spacing was 1.5 x 3.0 m (5 x 10 ft) staggered for a sprinkler design pressure of 0.5 bar (7.5 psi)

The results of the two tests are as follows:

- *Test No. 1: 18 sprinklers (165 m² [1,800 ft²])*
- *Test No. 2: 152 sprinklers (705 m² [7,600 ft²])*

Fire Protection Circa 1990 - 2014

CMDA vs. CMSA Sprinklers

K160 (K11.2)
CMDA Sprinkler

K160 (K11.2)
CMSA Sprinkler

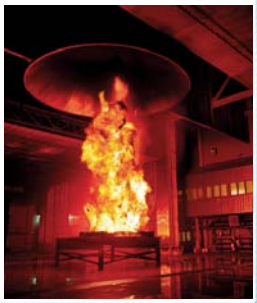
They look and are categorized differently. They are even tested for Approvals differently. However, do they perform differently?

Fire Protection Circa 1990 - 2014

CMDA vs. CMSA Sprinklers

Test Plan to Compare

- *Full-Scale Fire Test Comparison*
- *16 Total Tests (8 Comparison Tests)*
- *Open Frame Double-Row Racks with Class 2 or CUP*
- *K160 (K11.2), Upright Type*
- *Temperature Nominal 70˚C (160˚F)*
- *Standard-Response*



Fire Protection Circa 1990 - 2014

CMDA vs. CMSA Sprinklers

Conclusions:

CMDA and CMSA sprinklers could be considered equivalent if:

- *K-Factor*
- *Orientation*
- *Nominal Temperature Rating*
- *Nominal RTI Rating*
- *Rated Sprinkler Spacing*

Are the same

Fire Protection Circa 1990 - 2014

Sprinkler Attributes

By the mid-2000's, it was becoming apparent that the results of full-scale fire tests were being impacted by key attributes of the sprinkler at ceiling level. Key attributes include:

- *K-Factor*
- *Orientation*
- *RTI Rating*
- *Sprinkler Spacing*
- *Temperature Rating*

Let's take a look at two videos involving fire tests conducted at FM Global

Fire Protection Circa 1990 - 2014

Sprinkler Attributes

Test Conditions:

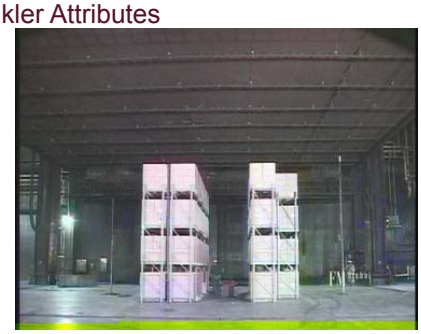
- *Storage Height: 6 m (20 ft) of CUP*
- *Ceiling Height: 9 m (30 ft)*
- *Storage Arrangement: Double-Row Rack Storage*

Test 1 Conditions:

- *K160 (K11.2) Upright 70˚C (160˚F)*
- *Standard-Response*
- *3 x 3 m (10 x 10 ft)*
- *2.4 m (8 ft) Aisle*
- *32 mm/min (0.80 gpm/ft²) Density*

Fire Protection Circa 1990 - 2014

Sprinkler Attributes



Fire Protection Circa 1990 - 2014

Sprinkler Attributes

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- *3 x 3 m (10 x 10 ft)*
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Test 2 Conditions:

- *K360EC (K25.2EC) Pendent 70˚C (160˚F)*
- *Quick-Response*
- *4.2 x 4.2 m (14 x 14 ft)*
- *1.2 m (4 ft) Aisle*
- *24 mm/min (0.60 gpm/ft²) Density*

Opens 25 Sprinklers

Fire Protection Circa 1990 - 2014

Sprinkler Attributes

Fire Protection Circa 1990 - 2014

Sprinkler Attributes

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Opens 1 Sprinkler

Fire Protection Circa 1990 - 2014

Assumed Performance

Today's commonly used sprinkler listings include:

- *Control Mode Density Area (CMDA)*
- *Control Mode Specific Application (CMSA)*
- *Suppression Mode (ESFR)*

These listings are based on the assumed performance of the sprinkler.

Let's look at some videos of fire tests conducted at FM Global involving these sprinklers…

Fire Protection Circa 1990 - 2014

Assumed Performance

Let's take a look at a fire test video that involves the following conditions:

- *Commodity: CUP*
- *Storage Height: 6 m (20 ft)*
- *Ceiling Height: 9 m (30 ft)*
- *Storage Arrangement: Double-Row Rack*
- *Aisle Width: 1.2 m (4 ft)*
- *Density: 24 mm/min (0.60 gpm/ft²)*
- *Ignition Under 1 Sprinkler*

Fire Protection Circa 1990 - 2014

Assumed Performance

Fire Protection Circa 1990 - 2014

Assumed Performance

Only one sprinkler opened and suppressed the fire.

What type of sprinkler was used at ceiling level?

Control Mode Sprinkler

QR K360EC (K25.2EC) Upright

Fire Protection Circa 1990 - 2014

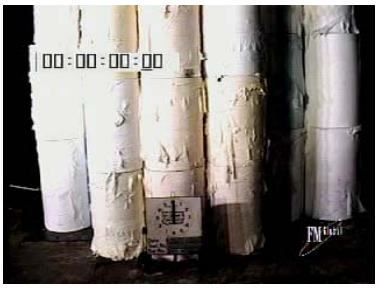
Assumed Performance

Let's take a look at another fire test video that involves the following conditions:

- *Commodity: Lightweight Roll Paper*
- *Storage Height: 7.5 m (25 ft)*
- *Ceiling Height: 12 m (40 ft)*
- *Storage Arrangement: On-Floor, On-End*
- *Storage Array: Closed Array*
- *Density: 48 mm/min (1.21 gpm/ft²)*
- *Ignition Under 1 Sprinkler*

Fire Protection Circa 1990 - 2014

Assumed Performance



Fire Protection Circa 1990 - 2014

Assumed Performance

A total of 16 sprinklers opened in 43 seconds and controlled the fire.

What type of sprinkler was used at ceiling level?

Suppression Mode Sprinkler

QR K200 (K14.0) Pendent

Fire Protection Circa Beyond 2014?

Over the past few years research at FM Global has focused its efforts to lead to the following potential modifications to Data Sheet 8-9:

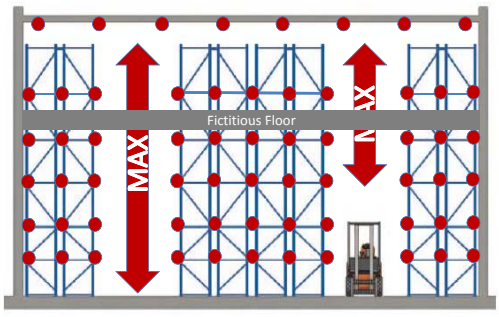
- *Determine in-rack sprinkler arrangements that can eliminate the of restriction of 3 m (10 ft) maximum storage above top level of in-rack sprinklers*
- *Determine how the key attributes of in-rack sprinklers can be used to increase the vertical distances required between in-rack sprinkler levels*

Fire Protection Circa Beyond 2014?

Over the past few years research at FM Global has focused its efforts to lead to the following potential modifications to Data Sheet 8-9:

- *Determine in-rack sprinkler lay-outs that will eliminate the need to hydraulically balance the in-rack system with the ceiling system*
- *Determine in-rack sprinkler lay-outs that will eliminate the need to account for simultaneous flow with the ceiling-level system*

Goal

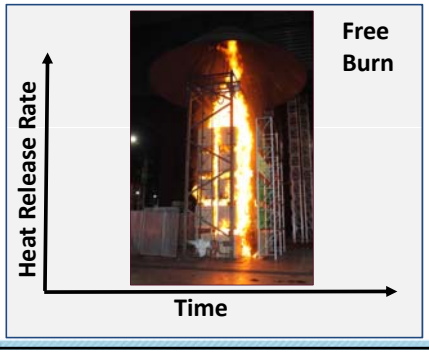


Goal

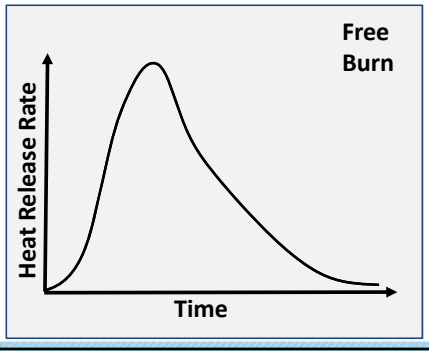
How do we achieve this goal?

- *Understand the fire growth characteristics taking place within a storage rack*
- *Understand the water application characteristics of various sprinklers installed as in-racks*
- *Understand how much water needs to be applied for the fire growth rate expected*
- *Learn how to model these phenomena to help reduce the number of full-scale fire tests needed*
- *Investigate potential solutions via small- and intermediate-scale fire testing*
- *Validate solutions via full-scale fire testing*

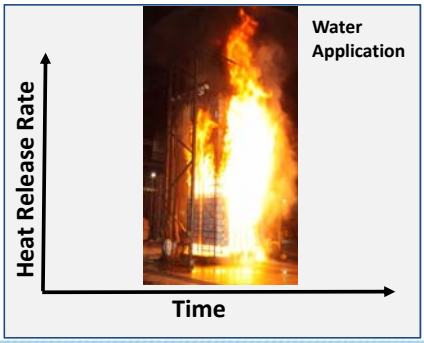
Fire Growth and Suppression



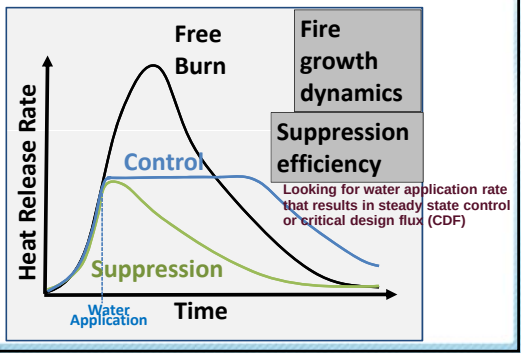
Fire Growth and Suppression



Fire Growth and Suppression

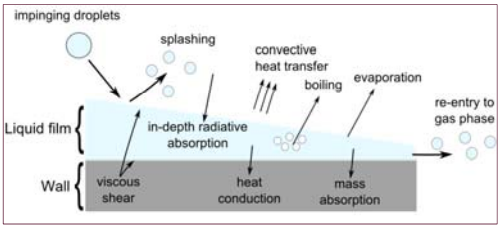


Fire Growth and Suppression



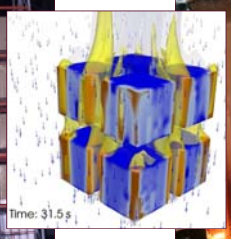
Sprinkler Spray Modeling

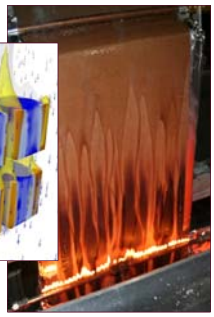
Water Transport Modeling



Water Transport Modeling

Water Transport Modeling



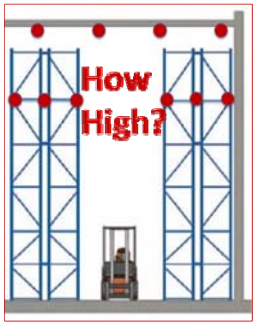


Fire Growth and Water Transport

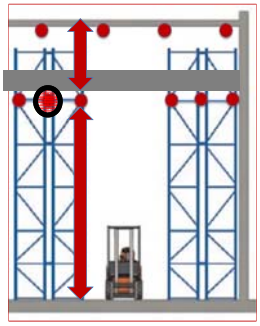


fire growth modeling | **water modeling** | **protection modeling**

Putting It All To The Test



Conclusions



- Vertical intervals
- Fictitious floor concept
- Storage above IRAS
- Flue space intersections
- Proximity to uprights
- Clearances between top of storage and in-rack sprinklers
- Other guidelines

Conclusions

rack sprinklers
Other guidelines

Thank You!

Questions?