Normalized Heat Load as Method for Barrier Assessments

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FIRE SAFETY REGULATIONS

- Separation of redundant safety systems
- Separation of fire hazards from safety systems
- Life safety
- Asset protection
- Defence-in-Depth

WHAT FIRE RESISTANCE RATING?

PRESCRIPTIVE

- CSA N293 – 3 hr
- CSA N393 – 3 hr
- NFPA 801 – 3 hr
- NFPA 805 – 3 hr

…or as determined by the Fire Hazard Analysis

PERFORMANCE BASED

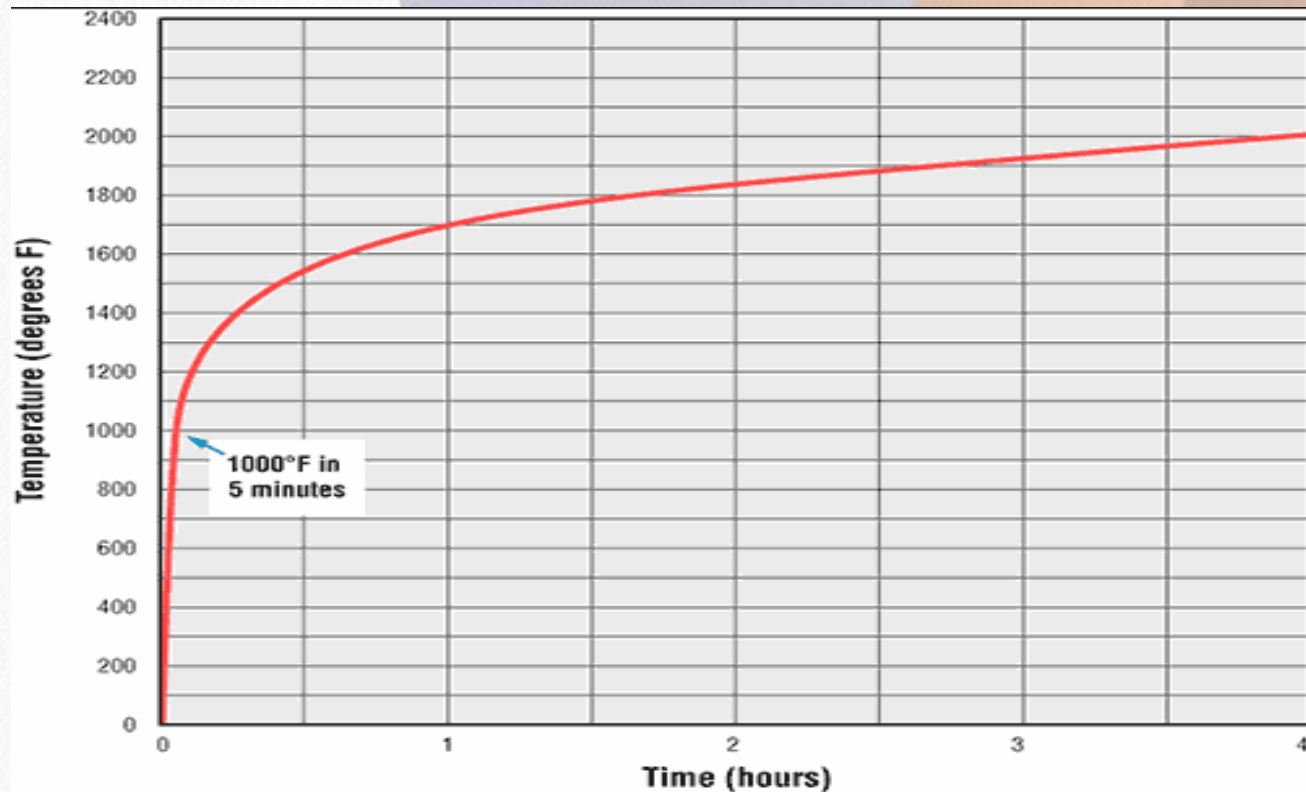- Fire resistance rating sufficient to prevent the spread of fire

How do we quantify an appropriate rating?

For existing facilities?

At design stages?

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FIRE RESISTANCE TEST

Fire resistance assigned in terms of ability to withstand the shown time – temperature exposure.
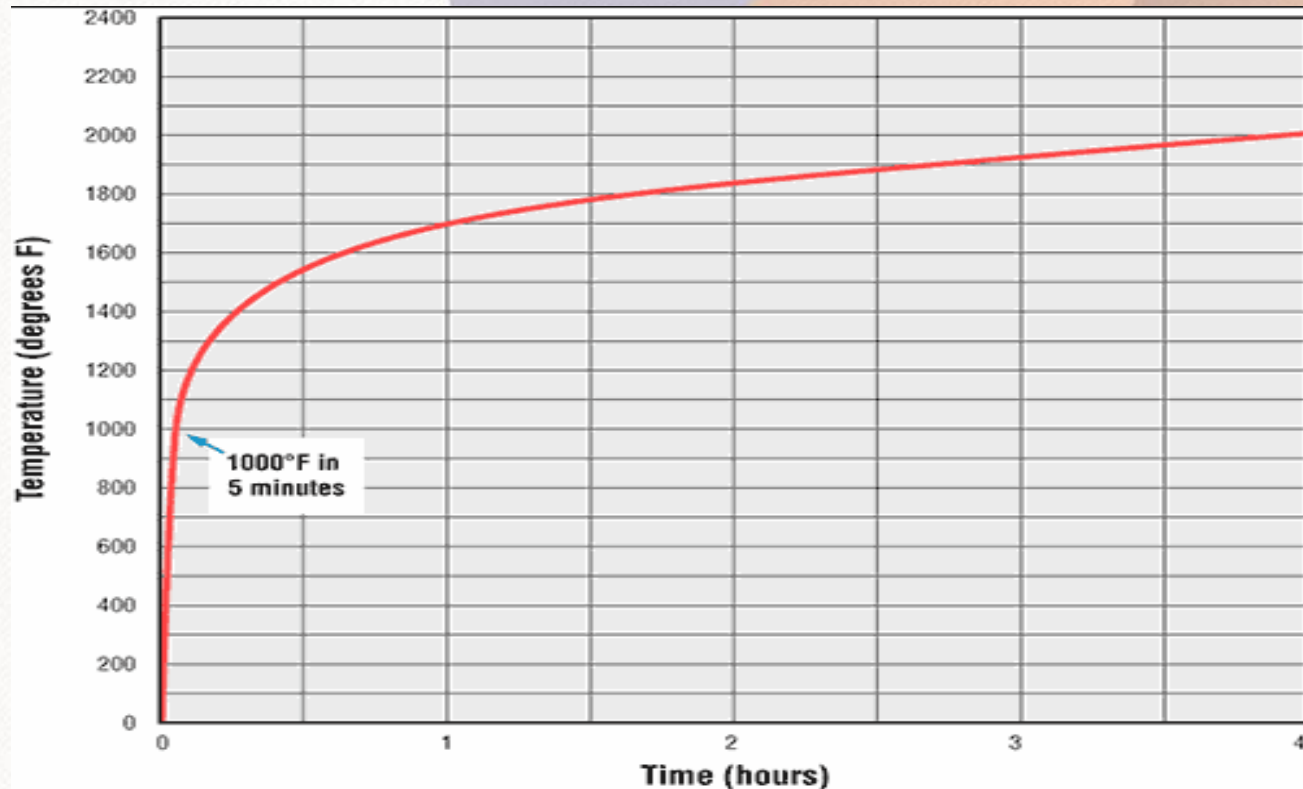

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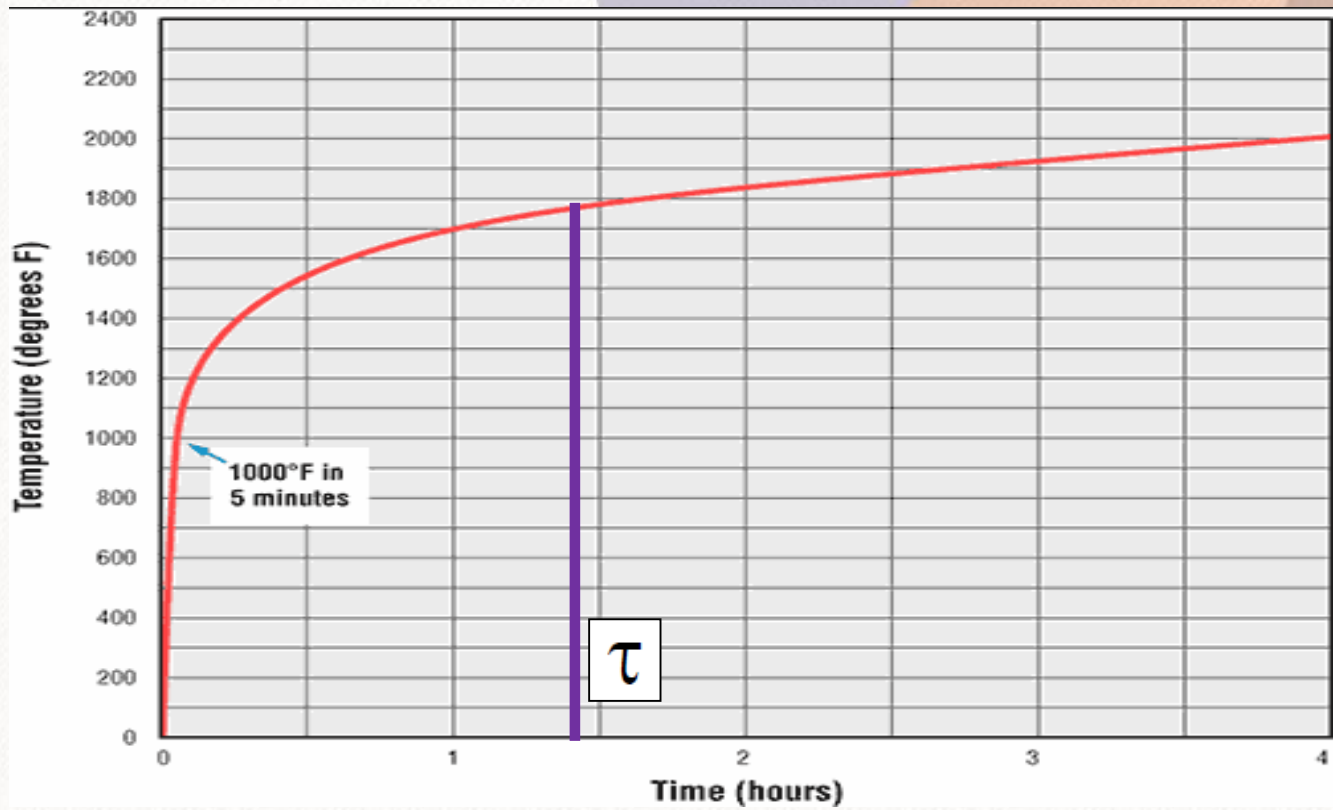# NORMALIZE HEAT LOAD

DEFINITION

The heat absorbed during fire exposure by a building assembly per unit surface area during the entire course of a fire divided by the thermal inertia.

T. Z. Harmathy;
Normalized Heat Load:
A Key Parameter in
Fire Safety Design;
National Research
Council, 1982.

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NORMALIZE HEAT LOAD

The NHL is equated to an equivalent fire resistance rating based on fire-resistance test (CAN/ULC-S101 or ASTM E119). The equivalent fire resistance rating is dependant on factors such as compartment fuel load, compartment construction materials and ventilation conditions.

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NORMALIZED HEAT LOAD

Calculation Variables

- Physical dimensions of the compartment

- Compartment boundary materials

- Compartment fuel load

- Compartment ventilation

- Length, width, height

$$A_T \sqrt{k\rho c}_{\,eff} = A_W \sqrt{k\rho c}_{\,W} + A_F \sqrt{k\rho c}_{\,F} + A_C \sqrt{k\rho c}_{\,C}$$

$$Q = \sum_{i=1}^{n} [\Delta Hc_i][M_i]$$

$$v_{eff} = n\,v = n\,A_d \sqrt{h}$$

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NORMALIZED HEAT LOAD

NHL based on set of Calculations

- Post flashover constant
- Fuel load based on wood
- Duration of fire
- Heat to boundary
- Fire resistance test duration

$$\beta = 3.0\, T(0) \left(\frac{v_{eff}}{A_T \sqrt{k\rho c}_{eff}} \right)^{1/3}$$

$$G = \frac{Q\,MJ}{18.8\,MJ\,kg^{-1}}$$

$$t_D = \frac{G}{0.1\,v_{eff}}$$

$$H_{eff} = \frac{3\beta}{2}\,t_D^{2/3}$$

$$\tau = \left(\frac{\beta}{229} \right)^{3/2} t_D$$

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FIRE DURATION & EQUIVALENT FIRE RATING

Compartment Dimensions W,L,H (m)	G (kg)	Doors[2]	β	t_D (min)	τ (min)
6, 6, 4.5	2,660	1	175.2	151	101
		2	221.6	75.5	71.8
6, 6, 6	2,660	1	164.3	151	91.7
		2	208.2	75.5	65.4
6, 6, 7.5	2,660	1	156.0	151	84.9
		2	197.6	75.5	60.5
9, 9, 4.5	2,660	1	143.5	151	74.9
		2	181.5	75.5	53.3
9, 9, 6	2,660	1	136.3	151	69.3
		2	172.3	75.5	49.3
9, 9, 7.5	2,660	1	130.4	151	64.8
		2	164.8	75.5	46.1

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BARRIER EVALUATIONS

REGULATORY REQUIREMENT

- Prescriptive Requirement (3h, 2h)
- Performance Based (prevent fire spread)

How do we quantify?

NORMALIZED HEAT LOAD SOLUTION

- Calculates theoretical maximum exposure and directly relates to fire rating
- Based on 4 variables
  - Dimensions
  - Boundary materials
  - Fuel loading
  - Ventilation
- Data available and used for Fire Hazard Analysis

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SOFTWARE SOLUTIONS FOR FIRE BARRIERS

Details of the fire barriers can be collected to support evaluations.

Barrier details must include and consider openings and proper protection of openings.

Barrier Details

Name	S005-S143		
Room	S1-143	Adjacent Room	S1-005
Barrier Location	Floor	Barrier type	Floor
Construction	Concrete Block	Complete	Yes
Thickness	158 mm	Effective	Yes
Fire Resistant Rating	3.0 Hours	Reliable	Yes
Required FRR	1.0 Hours	Openings In Barrier?	Yes
Barrier Required		Barrier Deficient	No
Justification			
Standard of Performance	[CAN/ULC-S101]		
Reference	[87-20030-2001-008-GA-F REV 13]		

Room: S1-143 - S/F Bay Ventilation Exhaust, Service Building

Show: ○ All Items   ● Items For Selected Room

Openings in Barrier S105- S143

	Opening ID ▲	Type ▲	Protected ▲	Reliable ▲	FRR ▲	Width ▲	Height ▲
🔍	S105-S143-01	Man Door	Yes	Yes	1.50	1.80	2.20
🔍	S105-S143-02	Ventilation Opening	Yes	Yes	1.50		
🔍	S105-S143-03	Pipe Penetration	Yes	Yes	2.00		
🔍	S105-S143-04	Duct Penetration	Yes	Yes	1.50		

4 items [#1 to 4 of 4]

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FIRE BARRIER REPORT

Software can be programmed to conduct Normalized Heat Load calculation to determine Equivalent FRR (h)

Software provides consistency of reporting for owners, operators and regulators

Deficiencies can to linked to other assessments and recommendations

Normalized Heat Load calculation demonstrates adequacy of barriers in preventing fire spread.

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S1-143 - S/F Bay Ventilation Exhaust, Service Building

Equivalent FRR (h)					1.89

Room Barriers

Adjacent Room	Barrier Type	Construction	Barrier FRR (h)	Barrier Satisfactory?	Technical Resolution
R1-101	Wall	Concrete NW	3.00	Yes	
S1-001	Wall	Concrete Block	2.40	Yes	
S1-002	Wall	Concrete Block	2.40	Yes	
S1-003	Floor	Concrete NW	3.00	Yes	
S1-005	Floor	Concrete Block	2.00	Yes	
S1-006	Floor	Concrete NW	3.00	Yes	
S1-007	Wall	Concrete Block	2.40	Yes	
S1-008	Floor	Concrete NW	3.00	Yes	
S1-009	Floor	Concrete NW	3.00	Yes	
S1-030	Floor	Concrete NW	3.00	Yes	
S1-105	Wall	Concrete Block	2.00	Yes	
S1-113	Wall	Concrete Block	2.00	Yes	
S1-118	Wall	Concrete Block	2.00	Yes	
S1-121	Wall	Concrete Block	2.00	Yes	
S1-122	Wall	Concrete Block	0.75	No	Barrier FRR based on door opening. See Recommendation FS-012.
S1-124	Wall	Concrete	3.00	Yes	

S1-122 - D2O in H2O Monitoring, Service Building

Equivalent FRR (h)					0.37

Room Barriers

Adjacent Room	Barrier Type	Construction	Barrier FRR (h)	Barrier Satisfactory?	Technical Resolution
S1-003	Floor	Concrete NW	3.00	Yes	
S1-023	Floor	Concrete NW	3.00	Yes	
S1-121	Wall	Concrete Block	0.75	Yes	
S1-143	Wall	Concrete Block	0.75	Yes	
S1-224	Floor	Concrete NW	3.00	Yes	

RESULTS OF NHL METHOD USED IN A BARRIER ASSESSMENT FOR A SINGLE UNIT PLANT

ASSESSMENT PERFORMED	NUMBER OF BARRIERS	BARRIERS TO BE RESOLVED
Total Number of Required Fire Barriers	894	894
Barriers meeting Prescriptive Requirements	480	414
Barriers with Fire Ratings > NHL Equivalent Fire Rating	149	265
Barriers with Adequate Fire Ratings based on Combustible Load and Automatic Fire Protection Measures (i.e. Automatic Suppression and Detection)	236	29

Of these 29 barriers, 11 were a result of penetrations requiring fire-stopping, 8 were a result of unknown door ratings, 6 barriers required upgrades to unprotected openings and the remaining 4 barriers required construction improvements.

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QUESTIONS?
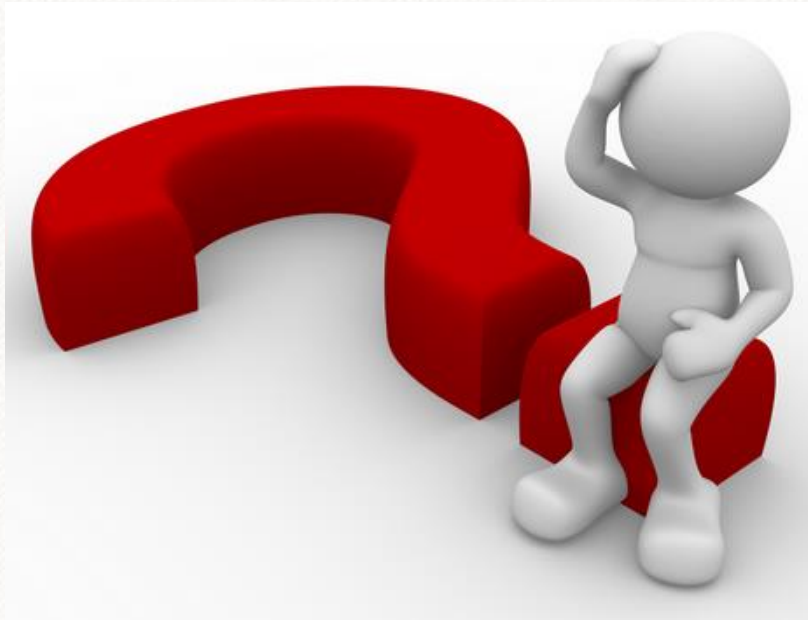
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