APPENDIX 16

DETERMINATION OF DESIGN FIRES FOR INDUSTRIAL PREMISES

1 OBJECTIVE

1.1 To determine the design fire size and perimeter of fire for purpose of calculating the capacity of the natural smoke ventilation or engineered smoke control system.

2 SCOPE

2.1 This set of requirements is only applicable to sprinklered industrial premises (factory and warehouse) without in-rack sprinklers and limited to the design of smoke control system based on clause 7.6 of the Fire Code (i.e. prescriptive-based approach).

3 DETERMINATION OF DESIGN FIRE SIZE

3.1 Fire growth

3.1.1 The fire growth can be evaluated by the following generic fire growth curve (also referred to as 't^2 fire'), that represents the general types of combustible material present within an enclosure:

$$Q_{max} = \propto (t-t_i)^2 \text{ ---------- equation (1)}$$

where

Q_{max} = heat release rate (kW);

$\propto$ = fire growth parameter (kJ/s^3);

t = time (s);

t_i = time of ignition (s) (taken here as zero)

The fire growth parameter varies with the fire load density and the fire load Configuration factor. However, for purpose of design, fire growth parameter can be generally defined as follows:

Table 1: Fire growth parameter

Fire growth rate	Fire growth parameter (kJ/s^3)	Time for Qg = 1MW (s)
Slow	0.0029	600
Medium	0.012	300
Fast	0.047	150
Ultra-fast	0.188	75

Note: Qualified Person (QP) or Fire Safety Engineer (FSE) has to justify the appropriate fire growth rate that is applicable through available literature or standard. In the instance where the fire growth rate lies in between the range as stated above, the QP/FSE is to use the more conservative fire growth rate
e.g. if the fire growth rate is between 'medium' and 'fast', the 'fast' fire growth rate is to be used.

3.2 Design Fire – Sprinklered

3.2.1 The heat output of the design fire is assumed to increase according to equation (1) Until sprinkler operation is deemed to occur at time t_s. Following sprinkler operation, the heat output of the fire is considered to remain constant.

3.2.2 The capacity of the smoke control system shall be based on the fire size that is controlled by activation of 2nd ring of sprinklers.

3.2.3 The operation of the sprinkler system at t_s and the corresponding fire size can be determined by hand calculations based on fire engineering principles or the use of fire engineering tools.

Whichever approach is used, the following design factors governing its calculation are as follows:

(a) Rate of fire growth

The type of fuel load and its configuration in the premises shall govern the rate of fire growth which can be represented using equation (1) and table 1.

(b) Sprinkler response time index (RTI)

The RTI is the thermal sensitivity of the sprinkler and shall be based on the manufacturer's specification.

Example:

Standard response sprinkler – 105 $m^{0.5}s^{0.5}$; Fast response sprinkler - $50m^{0.5}s^{0.5}$; ESFR - 26 $m^{0.5}s^{0.5}$

(c) Temperature rating of sprinkler

The operating temperature of the sprinklers shall be based on BS EN 12845 (e.g. 141^0C or 68^0C).

(d) Ambient temperature

Room temperature for air-conditioned space and non-air conditioned space can be taken as 25^0C and 30^0C respectively.

(e) Ceiling height

The ceiling height shall be based on the height, measured from the finished floor level to the soffit of the ceiling/roof.

(f) Spacing of sprinkler above fire

Sprinkler spacing shall be based on BS EN 12845 (e.g. 3m by 3m or 4m x 3m).

3.2.4 The capacity of the smoke control system shall also take into consideration the possibility of forklift or general goods vehicle on fire along the internal ramps/driveways. For design purpose, the design fire size shall be taken as follows:

Type of vehicle	Design fire size
Forklift or car	4MW
General goods vehicle	10MW

Table 2

4 DETERMINATION OF PERIMETER OF FIRE

4.1 Fire Perimeter for forklift / car and goods vehicle

4.1.1 The fire perimeter is used to determine the mass flow rate of smoke. For forklift or general good vehicle, the perimeter of fire shall be taken as follows:

Type of vehicle	Perimeter of fire
Forklift or car	5m x 2m
General goods vehicle	9m x 2.5m

Table 3

4.2 Fire perimeter other than for forklift/car and general goods vehicle

4.2.1 Other than for forklift/car and general goods vehicle, the following equation is used to calculate the fire perimeter for a square fire of equal sides:

$P = 4(Q_c/Q_r)^{1/2}$ ---------- equation (2)

where

P = fire perimeter (m);

Qc = convective heat output = $0.7Q_{max}$ (kW);
Qr = heat release rate per unit area (kW/m^2), see Table 4

Where elongated storage configurations such as racking or shelving are used, the fire perimeter is determined using the following equation:

$P = 2[Q_c/(Q_r xd)]$ ---------- equation (3)

where

Q_c = convective heat output = $0.7Q_{max}$ (kW);

Q_r = heat release rate per unit area (kW/m^2), see **Table 4;**
d = depth of rack (m)

For purpose of calculating the fire perimeter, the values for Q_r given in Table 4 are used.

Building Use	Heat release rate per unit area, Qr (kW/m^2)
Industrial	260
Storage	500

Table 4

5 OTHER DESIGN APPROACH

The QP/FSE may adopt a different design approach using recognized standards in determining the design fire size and perimeter of fire. However, should the design approach differ from this set of guidelines, the QP/FSE is required to obtain consent from the MFRS.