SINGAPORE CIVIL DEFENCE FORCE
FIRE SAFETY AND SHELTER DEPARTMENT
HQ SINGAPORE CIVIL DEFENCE FORCE
91 Ubi Avenue 4 Singapore 408827
Website: http//:www.scdf.gov.sg

Please quote our ref. no. in all future correspondences

CD/FSSD/12/01/04/04/02

DID: 68481407
FAX: 68481493

27 November 2008

Registrar, Board of Architects (BOA)
Registrar, Professional Engineers Board (PEB)
President, Singapore Institute of Architects (SIA)
President, Institution of Engineers, Singapore (IES)
President, Association of Consulting Engineers, Singapore (ACES)

Dear Sir/Mdm

DESIGN FIRE SIZE FOR CALCULATION OF SMOKE VENTILATION SYSTEM IN INDUSTRIAL PREMISES

Currently, clause 7.6.3 in the Fire Code states that the capacity of the engineered smoke control system shall be calculated based on the incidence of a likely maximum fire size for a sprinkler controlled fire. The recommended fire sizes for buildings of purpose groups IV (office), V (shop) and VII (place of public resort) are stated in the Fire Code. However, for occupancies other than the above, the maximum fire size is to be determined by the Qualified Person (QP) who designs the engineered smoke control system.

2. SCDF has thus received many consultation requests from QPs on the fire size in terms of heat output and perimeter of fire that is to be used to calculate the capacity of the smoke ventilation system for purpose groups VI (factory) and VIII (storage).

3. In view of the above, a set of requirements is attached to facilitate the calculation of fire size for sprinklered industrial premises without in-rack sprinklers. Its scope is also limited to the design of smoke ventilation system based on clause 7.6 of the Fire Code (i.e. prescriptive-based approach). For the small number of industrial premises which do not fall within the scope of the the requirements, e.g. presence of in-rack sprinklers, the QP is advised to seek consultation with the SCDF.

4. The determination of fire size involves the application of relatively straightforward fire engineering principles. As such, while SCDF would prefer a Fire Safety Engineer (FSE) to undertake this task, it has no objection if a PE (Mechanical) deems himself or herself to be sufficiently competent to undertake this task. If the FSE undertakes this task, the information on the fire size is to be certified by the FSE and furnished to the PE (Mechanical), who designs the smoke ventilation system, via a letter and supporting documents (in justifying the fire size). For administrative purpose, the letter and supporting documents are to be submitted together with the plans to the SCDF for approval.

5. This circular shall take immediate effect. We appreciate it if you could convey the contents of this circular to your members. The circular is also available for viewing in CORENET-einfo:http://www.corenet.gov.sg/einfo and SCDF internet website – http://www.scdf.gov.sg/.

6. For enquiry or clarification, please contact Mr Heng Chai Liang at DID 68481452.

Yours faithfully,

(transmitted via e-mail)

Poon Keng Soon
Secretary, FSSD Standing Committee
for Commissioner
Singapore Civil Defence Force

cc
All members of FSSD Standing Committee
President, REDAS
President, IFE
President, SISV
CEO, BCA
CEO, URA
CEO, HDB
CEO, PSA
CEO, JTC
CE, LTA
CE, TUV SUD PSB – (Attn : Ms Tan Chiew Wan/Mr. Lau Keong Ong)
CE, SPRING Singapore – (Attn : Mr. Teo Nam Kuan)

FIRE SAFETY AND SHELTER DEPARTMENT
SINGAPORE CIVIL DEFENCE FORCE

FIRE SAFETY REQUIREMENTS FOR DETERMINATION OF DESIGN FIRES FOR INDUSTRIAL PREMISES

FSR 4:2008

Effective Date : 27 Nov 2008

Released by :

Fire Safety Consultation Branch
Fire Safety & Shelter Department

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:

$Q_{max} = \propto(t-t_i)^2$ ---------------------------------- **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:

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

Table 1

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 such as the SFPE Handbook. 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 such as FPETool from National Institute of Standards and Technology (NIST). 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 - 50$m^{0.5}s^{0.5}$;
ESFR - 26 $m^{0.5}s^{0.5}$

c) Temperature rating of sprinkler
The operating temperature of the sprinklers shall be based on SS CP 52 (e.g. 141^{0}C or 68^{0}C).

d) Ambient temperature
Room temperature for air-conditioned space and non-air conditioned space can be taken as 25^{0}C and 30^{0}C 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 SS CP 52 (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 goods 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);
Q_c = convective heat output = $0.7Q_{max}$ (kW);
Q_r = 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, Q_r (kW/m^2)
Industrial	260
Storage	500

Table 4

5. CAUTIONARY NOTE

The application of FPETool from NIST or any other software in determining the activation time of the sprinkler system and the corresponding fire size has its limitations. Some of the software programs are based on Alpert's correlations where a number of fundamental assumptions are made such as flat smooth ceilings, unconfined smoke flow, axisymmetric plumes (not near walls or corners), location of detector close to the ceiling, etc. Such assumptions must thus be understood and considered by the user.

6. 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 SCDF.