FIRE SAFETY SEMINAR 2004



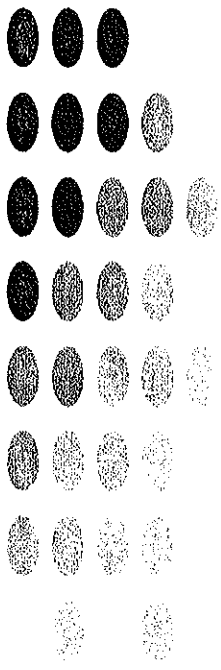
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Amendments To The Fire Safety Act To Facilitate A Performance-Based Fire Safety Regulatory System





By

Mr. Heng Chai Liang

Head, Performance Based Plan

Verification Section

Fire Safety & Consultation Branch

Fire Safety & Shelter Department

AMENDMENTS TO THE FIRE SAFETY ACT TO FACILITATE A PERFORMANCE-BASED REGULATORY SYSTEM

INTRODUCTION

The Fire Safety Act (FSA) provides for the fire safety regulations and effective enforcement of fire safety standards. In the last seminar, an overview of the performance-based regulatory system was presented, in which building designers are given more flexibility in designing their fire safety solutions. This paper presents the amendments to the FSA to adopt a performance-based approach towards fire safety. The Fire Safety (Amendment) Bill was passed in Parliament in February 2004.

2 The scope of this paper is therefore to highlight the major changes in the Act pertaining to the preparation and approval of a performance-based fire engineering plan and the regulation of fire safety engineers who will be solely authorized to prepare and review such plans.

BACKGROUND

3 Currently, fire safety standards for buildings in Singapore are governed by the Code of Practice for Fire Precautions in Building (Fire Code). The existing Code prescribes specific fire safety requirements and measures without stating their intentions. In this respect, architects have to adhere strictly to the requirements specified in the Code.

4 This strict adherence to the requirements has led SCDF to embark on a more flexible performance-based approach to fire safety design as an alternative to the current prescriptive approach. In fact, Qualified Persons have already proposed performance-based alternative solutions to SCDF and sought waivers from compliance with the Fire Code requirements. Some examples of buildings where alternative solutions have been used are the Singapore Expo, the Esplanade, and Changi Airport Terminal 3.

5 In view of the global trend towards using a performance-based fire safety engineering approach, as well as through SCDF's regular dialogues with professional bodies and academia on fire safety issues, the proposal for a new performance-based fire safety engineering approach took form and shape.

6 The Fire Code will be amended to incorporate the performance provisions, which would specify the desired fire safety objectives. It is then up to the building designers to devise their own appropriate fire safety solutions to meet those objectives. The proposed fire safety engineering approach will not compromise the current high levels of fire safety, and is in line with the approach to reduce over-regulation by the Government and becoming pro-business. It is also to be emphasized that the prescriptive measures will still be maintained in the Fire Code because it is still commonly used in standards buildings. Designs based on prescriptive approach are deemed to have satisfied the fire safety objectives. Hence, the fire safety works may be designed by prescriptive or performance-based approach, or a hybrid of both.

CHANGES TO THE ACT

7 The major changes involve amending 3 existing sections and introducing 6 new sections in the FSA. This paper will not elaborate the details of each clause in the FSA but will explain what the changes entail. For details, reference may be made to the Fire Safety (Amendment) Act 2004, which can be purchased at the Singapore National Printers Pte. Ltd. (SNP).

Section 2 – Interpretation

8 In this section, new definitions are introduced and these include 'alternative solution', 'fire performance requirements', 'fire safety engineer', and 'peer reviewer'.

9 Alternative solution is defined as engineering solution for the fire safety works to satisfy any fire performance requirements in the Fire Code, being a solution that is based on —

(*a*) a deterministic or probabilistic analysis of fire scenarios or both types of analysis;

or

(*b*) a quantitative or qualitative assessment of design alternatives or both against the fire performance requirements in the Fire Code,

using engineering tools, methodologies and performance criteria as may be acceptable to the Commissioner, but does not include engineered smoke control systems where the usage and design are in accordance with the Fire Code

10 'Fire performance requirements' means the objectives as are specified in the Fire Code in respect of fire safety works.

11 'Fire safety engineer' refers a person who is registered as a fire safety engineer under this Act.

12 'Peer reviewer' refers a fire safety engineer who is appointed to review and assess whether any alternative solution in plans for any fire safety works that is prepared or proposed by another person satisfies any fire performance requirements.

Section 23 – Fire Safety Works

13 This amended section provides a different process where plans for fire safety works are to be prepared using a performance-based approach and for their approval by the Commissioner. Where plans for fire safety works are to be prepared using a performance-based approach using an alternative solution to satisfy a fire performance requirement, the person for whom the fire safety works are to be carried out must appoint a fire safety engineer to prepare or supervise the preparation of those plans or part thereof containing the alternative solution, and another fire safety engineer as peer reviewer to review and assess those plans.

14 The Commissioner may, without checking such plans, approve them if the plans are accompanied by a certificate from a peer reviewer who has reviewed and assessed those plans as satisfying the fire performance requirements. Like in the case of other plans for fire safety works done by architects and professional engineers, the Commissioner may conduct random checks on such approved plans prepared using a performance-based approach, and revoke his approval of the plans.

Section 25 – Appointment and duties of qualified persons

15 This section is amended to provide that where the approved plans for fire safety works use a performance-based approach, the person for whom the fire safety works are to be carried out must appoint a fire safety engineer to supervise the carrying out of those works. Therefore, for a building plan which contains both prescriptive and performance aspects of fire safety works - which will very likely be the case - the QP who prepared the plans is to supervise both aspects and the fire safety engineer who supervised the preparation of the plan containing the alternative solution, is to supervise that aspect of the works.

Part IIIA of FSA

16 These new sections - 22A to 22F - reside in the New Part IIIA, which is on 'Fire Safety Engineers'.

Section 22A – Duties of fire safety engineers

17 Section 22A describes the duties and responsibilities of fire safety engineers. Only a fire safety engineer can prepare or propose, or supervise a qualified person in the preparation of, alternative solutions to satisfy fire performance requirements in the Fire Code. In addition, only a fire safety engineer can be a peer reviewer, that is, to review and assess whether an alternative solution prepared by another satisfies the fire performance requirements in the Fire Code. A fire safety engineer will be under a duty to exercise due diligence in the performance of his duties.

18 In addition, when reviewing and assessing whether an alternative solution prepared by another satisfies the fire performance requirements, a peer reviewer must not have any professional or financial interest in those fire safety works or related building works, or in the building in which those works are to be carried out. As to what constitutes professional or financial interest, these are specified in the Act and they are similar to that specified for Registered Inspectors.

Section 22B – Registration of fire safety engineers

19 Section 22B deals with the registration of fire safety engineers by the Commissioner. To be registered as a fire safety engineer, a person must have the necessary qualifications and practical experience. Basically, these are to possess a Bachelor or Master degree in the field of fire safety engineering, to have at least 5 years experience in the design of fire safety works in buildings and to attend and pass an interview conducted by a committee of persons. These will be prescribed in the Fire Safety (Fire Safety Engineers) Regulations.

20 A committee of persons may be appointed by the Commissioner to assist him in considering applications for registration as fire safety engineers. The details of this committee will also be spelt out in the Regulations. Basically, it will be chaired by Director, Fire Safety and Shelter Department, and comprises 2 senior officers from the Force and representatives from the professional institutions.

Section 22C – Disciplinary action against fire safety engineers

21 Section 22C provides for disciplinary action against fire safety engineers. After considering the report of an Investigation Committee into any complaint or information received regarding a fire safety engineer, the Commissioner may either cancel the registration of a fire safety engineer, suspend his registration for up to 12 months, impose a penalty of up to $5,000, censure in writing, require undertakings from or impose restrictions on the practice on the fire safety engineer concerned. The disciplinary action will be taken only after the fire safety engineer concerned is given reasonable opportunity of being heard. The fire safety engineer has 14 days to appeal to the Minister if he is aggrieved by the decision of the Commissioner and the decision of the Minister on the appeal shall be final.

Section 22D – Investigation Committee

22 Section 22D provides for the formation of Investigation Committees to look into written complaints against or information about any fire safety engineer when received by the Commissioner. This is equivalent to the Inquiry Committee formed to look into complaints against a Registered Inspector. An Investigation Committee comprises a chairman, 2 fire safety engineers who are not members of the Singapore Civil Defence Force and 2 others who are members of the Singapore Civil Defence Force. An Investigation Committee will have power to require evidence to be given on oath and require the production of plans, books, documents and papers.

23 In the event that the complainant withdraws his complaint before the Investigation Committee is constituted or before the investigation by the Committee is concluded, the Commissioner may, notwithstanding such withdrawal, constitute an Investigation Committee and direct it to investigate, or may direct the Investigation Committee to continue with its investigation, into the matter, and the Investigation Committee shall comply with that direction.

Section 22E – Fire Safety Engineers Discipline Panel

24 Section 22E establishes the Fire Safety Engineers Discipline Panel, from which Investigation Committees may be constituted. This is the equivalent of the Inquiry Panel from which the Inquiry Committee is constituted as in the case of disciplinary process for Registered Inspectors. Persons are appointed to the Panel by the Minister for a term of 2

years, and may be re-appointed. These persons shall comprise such number of fire safety engineers who are not members of the Singapore Civil Defence Force as the Commissioner may determine and such number of members of the Force as the Commissioner may determine.

Section 22F – Register of fire safety engineer

25 Finally, section 22F deals with the register of fire safety engineers, and the removal and reinstatement of names from the register. The register shall contain the names of all persons registered as fire safety engineers, the qualifications by virtue of which they are each so registered and such other particulars in relation to the person as may from time to time be determined by the Commissioner.

26 For FSEs whose registration are canceled or suspended, their names and particulars will be removed from the register and the fire safety engineer concerned shall, within 7 days of being so notified, surrender to the Commissioner the certificate of registration issued to him and the Commissioner shall cancel any certificate of registration issued to the fire safety engineer concerned. In the case of FSEs whose registration has been suspended, at the end of the period of suspension the Commissioner shall, within 7 days of that period ending, restore the person's name and particulars to the register of fire safety engineers and re-issue to him a fresh certificate of registration.

SCHEDULE FOR IMPLEMENTATION OF PERFORMANCE-BASED REGULATORY SYSTEM

27 It is to be noted that the highlighted changes only pertains to the FSA. For the performance-based regulatory system to be effected, changes to the regulations are required as well and these are targeted for gazette in April/May 2004. Thereafter, SCDF will conduct the registration exercise for fire safety engineers prior to implementation of the system, targeted in July 2004.

CONCLUSION

28 In conclusion, the legislative changes to effect the performance-based regulatory system will provide a more pro-business and an alternative framework for the building industry in Singapore. They are necessary to ensure that the Act remains relevant to our needs and will enable us to maintain one of the highest fire safety standards in the world while being flexible on the aesthetic design of the building.

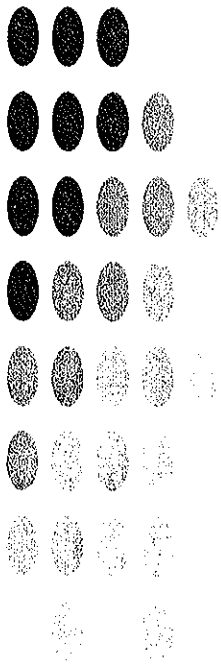
Prepared : EO Heng Chai Liang

Head, Performance-Based Plan Verification Section

Fire Safety Consultation Branch, FSSD

Documentation Requirements For Submission Of Performance-Based Projects





By

Mr. Edmund Choo

Performance Based Plan Verification Section

Fire Safety & Consultation Branch

Fire Safety & Shelter Department

DOCUMENTATION REQUIREMENTS FOR SUBMISSION OF PROJECTS INVOLVING PERFORMANCE-BASED SOLUTIONS

INTRODUCTION

Proper documentation for a performance-based submission is of paramount importance. Documentation plays a role in determining the scope of work for each stakeholder, forms the evidence whereby to determine if due diligence have been accorded to the design, installation and maintenance processes on the part of the building practitioner. Documentation also serves as a reference platform for future fire safety engineering alteration works to existing performance-based designs. Hence there is a need to establish a rigorous documentation process to support the successful implementation of a performance-based plan regulatory framework.

KEY STAKEHOLDERS

2 The key stakeholders in the performance-based regulatory framework are :-

(a) Fire Safety Engineer (FSE)

The Fire Safety Engineer is responsible for drawing up appropriate fire safety strategies for buildings to meet the intent of the Code of Practice for Fire Precautions in Buildings using performance-based methodologies, and also incorporate the requirements of the other stakeholders. The FSE must be registered with the Singapore Civil Defence Force for the practice of fire safety engineering. He is expected to be knowledgeable in the application of the Fire Code (for both the performance-based and prescriptive provisions), fire dynamics and fire safety systems and be able to apply the appropriate measures to address the fire safety concerns of a building.

The scope of work of the Fire Safety Engineer is distinct from that of the QP. The FSE's scope covers the performance-based aspects of the fire safety submission and involves ensuring that the performance-based elements of the fire safety design integrate well with the prescriptive aspects to achieve the desired level of fire safety.

The QP is responsible in ensuring the prescriptive aspects of the Fire Code have been fully complied with. The Fire Safety Engineer is jointly responsible for the fire safety engineering works in the project.

(b) **Peer Reviewer (PR)**

The Peer Reviewer is another FSE, engaged by the building developer/owner, who is responsible for checking the performance-based solution prepared by the FSE and to see that it is appropriate and adequate for the particular project. The Peer Reviewer is required to submit an official report (Peer Reviewer's Report) to SCDF detailing his objective comments on the FSE's work for the particular project.

(c) **Registered Inspector (Fire Safety Engineering) RI(FSE)**

The RI(FSE) is a Registered Inspector who is also an FSE. His scope of work involves the checking of on-site installation of fire safety engineering works to be in accordance with the approved fire safety plans and to surface irregularities to code requirements to SCDF.

The Building Owner may engage an RI(FSE) for inspection of both fire safety engineering and prescriptive works related to his discipline. In this instance, the RI(FSE) will be responsible for inspecting prescriptive works relating to his discipline (Architectural or M&E) and the performance-based solution which may involve both architectural and M&E aspects.

The following Venn diagram illustrates the scope of inspection of works for RI(FSE), RI(Architectural) and RI(M&E):-

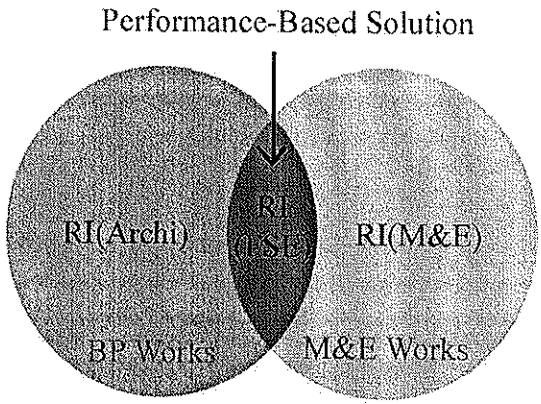


Figure 1 : Venn diagram illustrating scope of inspection works for RIs

3 The introduction of the Peer Reviewer and the RI (FSE) in the performance-based regulatory framework provides an independent and objective assessment to ensure that the performance-based design proposed by the FSE is able to stand up to scrutiny and is implemented on-site faithfully according to the approved design.

4 The other stakeholders in the process include the building owner, qualified persons, and SCDF.

DOCUMENTATION REQUIREMENTS

5 The documentation required in the performance-based plan submission process is as listed below:-

(a) Fire Safety Engineering Design Brief (FEDB)

Fire Safety Engineering Design Brief is a document summarizing agreed performance criteria and methods that will be used to evaluate trial designs. Generally, the FEDB would define the project scope, stakeholder and design objectives, identify goals, and develop performance criteria, design fire scenarios and trial designs.

The FEDB is to be prepared by the Fire Safety Engineer. The Fire Safety Engineer is advised to seek consultation with SCDF. This is to discuss and establish an understanding of the acceptability of his design proposition. Upon acceptance of the FEDB by SCDF, the FSE can proceed to evaluate the design that best meets the performance criteria.

(b) Fire Safety Engineering Report (FER)

The Fire Safety Engineering Report is another document to be prepared by the Fire Safety Engineer subsequent to the approval of the FEDB by SCDF. The report is to be submitted together with the plans, to SCDF for approval.

The report should convey the expected hazards, risks, and system performance over the entire building life cycle (i.e., construction, operation, renovation and demolition).

In short, the FEDB documents proposed conceptual designs, and the FSER takes it a step further in establishing whether the proposed conceptual designs in the FEDB can meet acceptance criteria for life safety and property protection, through detailed calculations, engineering judgement and scientific literature support.

(c) **Building Operations and Maintenance Manual (O&M)**

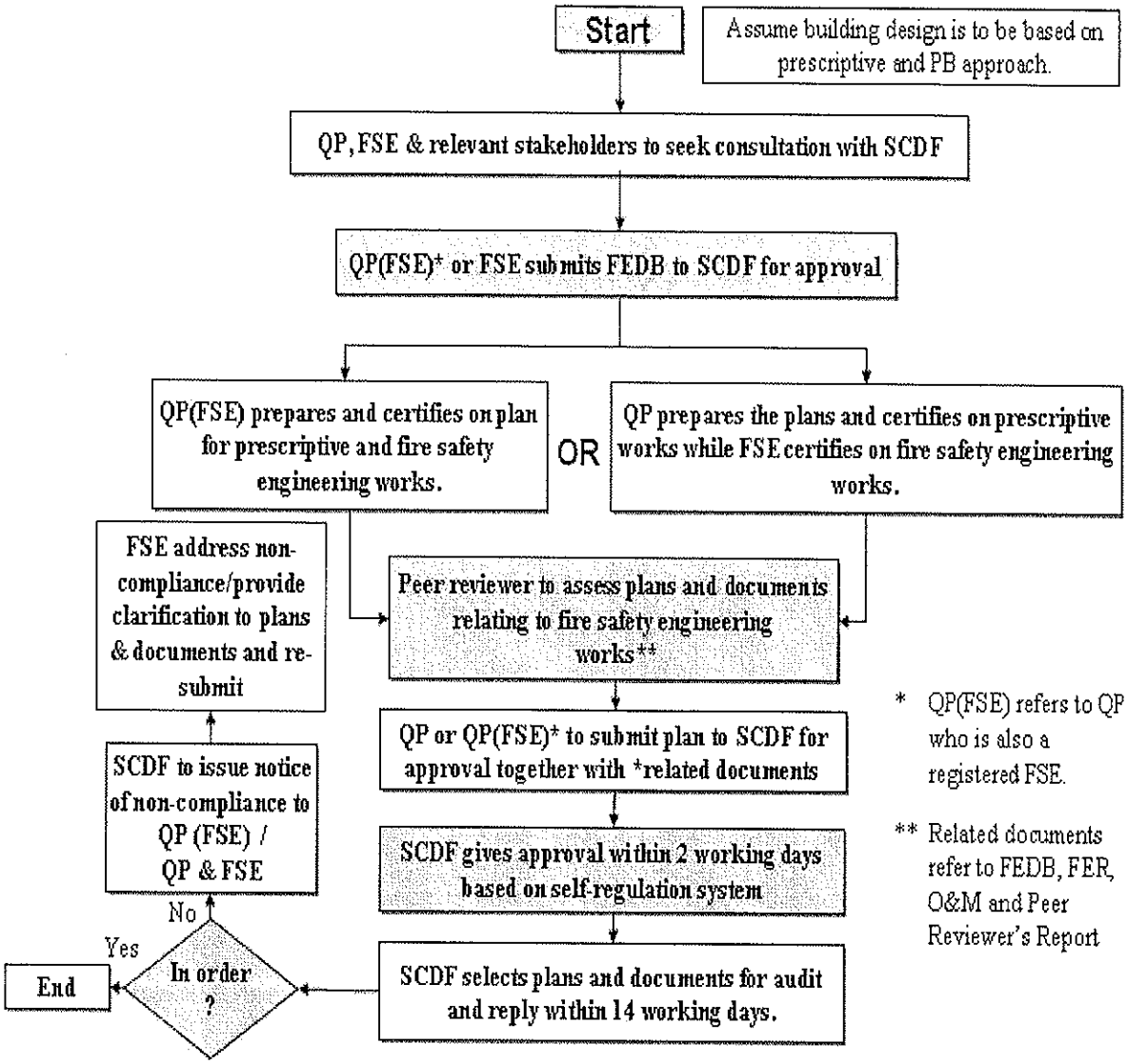
The O&M manual explains what the building operator should do to ensure that the components of the performance-based system are in place and operating properly. It also gives instructions to the building operator on the restrictions placed on the building, arising from the FSE's assumptions during design and analysis. These may include critical fire load, building use and occupancy, and reliability and maintenance of systems. Part of the O&M manual can be used to communicate to the tenants and occupants these limitations and their responsibilities. It can also be used as a guide for the renovations and changes to be carried out by tenants.

6 The required format for submission to SCDF the above-mentioned documents is listed in the Annex.

DOCUMENTATION REQUIREMENTS IN PERFORMANCE-BASED PLAN SUBMISSION PROCESS FLOW

7 This section highlights the appropriate documentation submission 'stops' in the performance-based plan submission process, and will provide you with an overview of the process flow.

8 The flow chart on the following page illustrates the performance-based plan submission process. The process flow is based on a building design that is part performance-based and part prescriptive, which would be the typical case for a performance-based submission. It is rare for a building to be fully designed to performance-based requirements.



9 The section below outlines the performance-based plan submission process:-

(a) Engaging FSE

The building owner is required to engage an FSE for the preparation of performance-based solutions as part of the plan submission to SCDF.

(b) Preparing FEDB

The FSE is required to produce a preliminary report – Fire Safety Engineering Design Brief (FEDB) to be submitted to SCDF for in-principle approval. The FEDB details the proposed fire safety engineering approach, methodology, and software tools etc. The FSE may consult SCDF on his FEDB proposal prior to its submission.

(c) Assessment of FEDB by Fire Safety Engineering Panel

The FEDB will be assessed by by SCDF. Upon the approval of the FEDB, the FSE can proceed to prepare the following documents:-

(i) Revised FEDB, if conditional approval is given
(ii) Fire Safety Engineering Report (FER)
(iii) Building Operations and Maintenance Manual (O&M)

In the event that the FEDB is disapproved, the FSE will to go through the process of consultation and re-submission of the FEDB for SCDF's consideration and approval.

(d) Engaging Peer Reviewer

After the preparation of the above documents by the FSE, the owner is required to engage a Peer Reviewer to assess the above documents and ensure that the performance-based solution is incorporated in the Building and M&E plans. The Peer Reviewer shall produce a report of his assessment and findings in a Peer Reviewer's report

(e) Plans Submission by QP

The Project QP is responsible for collating all the above documents for plan submission to SCDF.

Plans containing the performance-based solution shall be endorsed by both the QP and the FSE. QPs who are also qualified FSEs may endorse in the capacity of both the QP and the FSE.

(f) Audit Checks by SCDF

The submitted plans and documents may be selected by SCDF for subsequent audit checks.

(g) Engaging RI(FSE)

Upon completion of the fire safety works, the owner is required to engage a Registered Inspector (FSE) to inspect the performance-based aspects of the fire safety works. The RI(FSE) is a registered inspector who is also a qualified FSE.

CONCLUSION

10 Documentation is a major factor in determining the success of the performance-based system for fire safety. Proper document trails enables fire safety engineers, peer reviewers and registered inspectors to re-visit assumptions embedded into past performance-based designs, without needless reproduction and guesswork. Rigorous documentation helps ensure that all necessary grounds are covered in establishing and implementing performance-based designs. SCDF has thus put in place the necessary documentary requirements in the performance-based plan submission process to this end.

Prepared by: EO Edmund Choo
Performance-Based Plan Consultant
Performance-Based Plan Verification Section
Fire Safety & Shelter Department

DOCUMENTATION FOR PLANS INCORPORATING PERFORMANCE-BASED SOLUTIONS

	Type of document	Contents
1.	**Fire Safety Engineering Design Brief**	**i) Project scope** Define scope/extent of fire safety engineering works e.g. involve specific fire protection system components, new construction of a building, additions and alterations to partial building or whole building or renovation of an existing building for a change of use. The scope also serves to document the fire safety engineer's area of responsibility within the overall project. **ii) Identify relevant performance-based issues to be addressed.** **E.g.** **Location affected by PB Solution** **Relevant Prescriptive Clause** **Corresponding Root & Sub-Objectives** **Design Solution** **Acceptance Criteria** Atrium of Building A Commercial Complex Grid A/Z- 1/8 Clause 3.3.1 Table 3.3A

Requirement for element of structure to be fire rated to 1-hr

Root Objectives
- R3.1 and R3.3

Sub-Objectives
- S3.1, S3.3 and S3.9

Non-provision of the required 1-hr fire resistance rating to elements of structure at atrium through use of CFD fire modelling to demonstrate that atrium element of structure will not reach critical steel temperatures for anticipated fire loads at the atrium.

Attached sketch showing location of affected elements of structure at the atrium.

Steel temperatures for elements of structure at the atrium will not reach critical steel temperatures of 550 degrees Celcius for fire occurring at the atrium for anticipated fire loads.

iii) Building characteristics

Identify critical building characteristics such as

- Building classification and usage
- Building setback from boundary line
- Number of floors, area of each floor and their general layout

iv) Occupant characteristics

Identify dominant occupant characteristics such as

- Number and basis for calculation for occupant load and exit capacity
- Physical attributes eg handicapped, aged
- Fire Safety Manager/ Fire warden

		v) Fire hazards / fire scenarios Assess potential fire hazards in the building including ignition sources and fuel loads. Describe the plausible fire scenarios considered, why they were used and identify the 'worst credible' fire scenario(s). Any assumptions made must be justified. Select parameters for design fires. **vi) Trial designs** Identify trial design(s), ie fire safety measures for analysis and state the assumptions made and the sequence of operations of the proposed fire safety systems. **vii) Method of evaluation** Determine the method of evaluation (i.e. qualitative and/or quantitative). The method chosen must be well-documented (limitations and assumptions), well-validated and suitable for the tasks at hand. • If quantitative analysis is adopted, state the approach (deterministic or probabilistic) and specify the performance/acceptance criteria, sensitivity studies, uncertainties and safety factors. A comparison table of the generated outputs against the acceptance criteria is to be included. • If qualitative analysis is adopted, the basis on which engineering judgement is made must be clearly documented and appropriate references provided. **viii) Design parameters** Identify and select design parameters e.g. design occupant groups, design fire, etc. **ix) Notes of discussion / Consultations** Notes of discussion with SCDF are to be attached with the brief for reference. **x) References** Identify relevant reference information. **xi) Credentials and Endorsement of fire safety engineer** Include name, credentials and endorsement of the fire safety engineer who prepared the brief.

2.	**Fire Safety Engineering Report**	i) **FEDB** Include the approved FEDB in the report. (Note : How the performance criteria were developed, including any certainty or safety factors should be discussed. The selection of design fire scenarios and the basis used to select those fires should also be discussed). ii) **Assumptions & Limitations** State assumptions and limitations made during the assessment with regards to the fire safety engineering design. iii) **Evaluation** Show how the final design, that was selected from the trial designs, meet the performance criteria. The evaluation should include a description of the analysis method and the design tools used. Any computational tools used should be discussed along with the input parameters and output results. References should be given for all equations and all calculations should provide sufficient information for the entire design process to be followed clearly and precisely. As far as possible, graphs should be used instead of numerical printouts. Such printouts should only be included as an appendix, not in the main report. iv) **Critical design features** State the critical design features/parameters that must be maintained throughout the life cycle of the building in order for the design to function as intended. v) **Engineering judgement** State justification in applying engineering judgement, where it is used. vi) **Conclusions and recommendations** Justify the conclusions drawn from the assessment and associated recommendations. vii) **Summary** Summarise the fire safety measures.

viii) **Specifications**

State the specifications of the fire protection systems that are derived from the calculations and results within the report, including any particular construction requirements to ensure fire safety system is properly realised.
E.g. Specification of RTI and activation temperature for sprinkler system.
(Note : Simply referencing existing codes might not be adequate. For example, if the fire protection design is based on a particular spacing of sprinklers or sprinkler design density, then such characteristics of that sprinkler system must be clearly indicated.)

There should be specific instructions to the QP who will be detailing the design and incorporating into the plans.

ix) **Commissioning and maintenance**

Identify the commissioning and maintenance needs (e.g. its frequency) for the fire safety systems.

x) **Fire safety management**

Highlight specific procedures or processes that must be adhered to in order to achieve the desired level of safety.

xi) **References and citations**

Identify sources of information concerning the project from which data were obtained for purpose of assessment.

xii) **Credential and Endorsement of FSE**

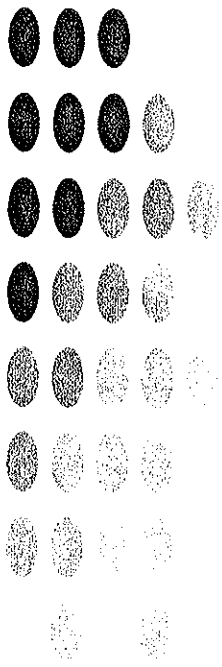
Include name, credentials and endorsement of the fire safety engineer who prepared the report.

3.	**Operations and Maintenance Manual**	**i) Role & responsibilities of building operator** State the role and responsibilities of the building operator in ensuring that the components of the performance-based design are in place and operating properly. **ii) Identification of sub-systems** Identify and describe the relevant sub-systems for the particular project and their interaction with each other. Eg. • Fire detection • Fire suppression • Emergency warning • Occupant evacuation **iii) Maintenance plan** • Develop maintenance plan for the proper functioning of the design system. • Establish inspection and testing regimes (including testing criteria) and their schedules. Note : Although some systems might be tested and inspected individually, the interconnections between systems should be periodically tested. • Documentation of inspections/testing and their results should be maintained with the building records. **iv) Restrictions** List the restrictions placed on the building operations. These restrictions may include critical fire load, building use and occupancy, and reliability and maintenance of systems. **v) Compensatory actions** Highlight compensatory actions that must be taken if a fire protection system is impaired or removed from service. **vi) Credentials and Endorsement of FSE** Include name, credentials and endorsement of the FSE who prepared the manual.

4.	**Peer Reviewer's report**	**i) Scope of review** State the documents being reviewed. **ii) Review process** Describe how the review was performed and state the references used. Note : (a) The review should not only address the checking of the calculations for the performance-based solution but also review the appropriateness and adequacy of the methodology used in obtaining the final result. (b) If the reviewer is not familiar with the methodology, or aspect thereof, used by the FSE, the peer reviewer may perform his own checks and determine if the design is acceptable. **iii) Highlight any reservations** Highlight concerns about any part of the documents being reviewed. Recommend additional studies, if any. **iv) Sugesstions of areas for improvement** **v) Conclusion** State the conclusion. E.g. Either of the following: (i) Documents reviewed are acceptable. (ii) Documents reviewed are acceptable pending further studies. (iii) Documents reviewed are unacceptable. FSE to revise the design. **vi) Credentials and Endorsement of peer reviewer** Include name, credentials and endorsement of the peer reviewer who prepared the report.

Case Studies On Local Performance-Based Projects





By

Cpt. Ng Kok Leong

Performance Based Plan Verification Section

Fire Safety & Consultation Branch

Fire Safety & Shelter Department

CASE STUDIES OF LOCAL PERFORMANCE-BASED PROJECTS

INTRODUCTION

Advances made in the field of fire safety engineering, coupled with the need for greater flexibility in building codes and designs, have enabled more countries to adopt or are in the process of adopting performance-based fire codes. The performance-based approach to fire safety design uses fire engineering principles, calculations and/or appropriate software modeling tools to satisfy the intentions of the Code of Practice for fire Precautions in Buildings 2002 or Fire Code. The use of fire safety engineering concepts and principles in fire safety design is not new here. In fact, SCDF has been receiving such submissions from time to time. However, currently, Qualified Persons (QPs) who deviate from the prescribed fire safety requirements are required to submit waiver application to the Waiver Committee, until such time when the performance-based system is implemented.

2. To provide an appreciation of the use of fire safety engineering principles and tools, this paper will present two case studies that were submitted as waiver applications to SCDF.

CASE STUDIES OF LOCAL PERFORMANCE-BASED PROJECTS

3. Case Study 1 – Separation Distance between Building and Relevant Boundary

(a) Description of building

This is a new 32-storey office building with one basement level.

(b) Non-Compliance

Clause 3.5.3 of the Fire Code 2002 states that "except where otherwise provided, unprotected areas in any side of a building shall comply with the following: from parts (a) to (d)". In particular, reference to part (c) of clause 3.5.3 – "the distance between the external wall of a building and the relevant boundary may be half that specified in Appendix B (as in the Fire Code 2002) if the building is fitted throughout with an automatic sprinkler system in compliance with the requirements in Chapter 6".

(c) Intention of the Clause

The intention of this clause 3.5.3 is to prevent the fire spread between adjacent buildings and this is achieved by providing the appropriate separation distance. Part (c) of the clause gives relaxation on the separation distance between buildings by allowing the separation distance to be halved if a building is fitted with sprinkler system as sprinklers have been proven to limit the fire spread.

(d) Building Geometry

In this project, the proposed building A is required to have a separation distance of 13.5m from it's relevant boundary, based on clause 3.5.3(c) and Table 1 of the Fire Code. However, there is only a distance of 11m separation between the two buildings as reflected in Figure 1, i.e. 6.5m from external boundary of building A to the relevant boundary, a shortfall of 7m in separation distance.

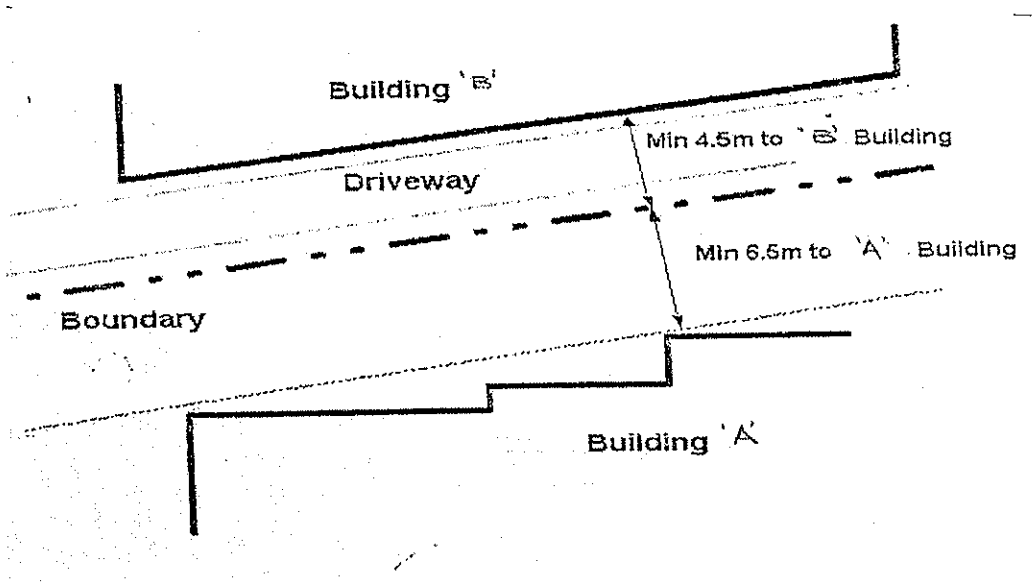


Figure 1 – Separation distance between building A and relevant boundary

(e) Acceptance Criteria

The Fire Safety Engineer (FSE) proposed that reference be made to Approved Document B of the Building Regulations [UK – Fire Safety (2000)] with respect to the acceptance criteria for fire spread from the subject building to an adjacent property via radiation exposure. It states that "the building is separated from the boundary by at least half the distance at which the thermal radiation intensity received from all unprotected openings in the wall would be **12.6KW/m^2** (in still air)"as referred in Figure 2.

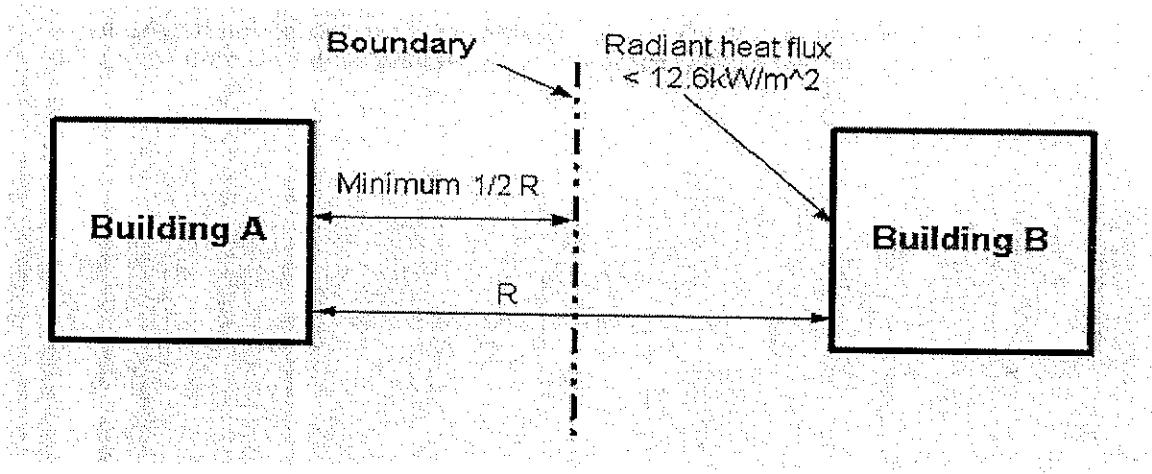


Figure 2 – Separation distances for calculation of acceptable unprotected facade

(f) Methodology

The methodology employed by the FSE was first to specify the possible fire scenarios based on the Architectural drawings and possible fire load arising from the intended activities within the building A that could cause fire spread to building B. With that knowledge, the heat release rates from the fire loads are determined based on the different fire scenarios in building A.

Next, the FSE used the radiant heat flux formulae as stated below [Fire Engineering Design Guide (1995)] to determine the radiation from an imaginary fire onto a point away from the fire.

$$I_r = k_1 Ö ó å (T_e^4 - T_r^4)$$

where

I_r is the radiant heat flux (kW/m^2);

k_1 is the radiation reduction factor (1.0 for non-rated glazing; 0.5 for fire-resistant glazing);

Ö is the configuration factor;

ó is the Stefan-Boltzmann constant (56.7×10^{-12} kW/m^2K^4);

å is the emissivity of the emitting surface;

T_e^4 is the temperature of the emitting surface (k); and

T_r^4 is the temperature of the receiving surface (k).

The configuration factor, Ö, for radiation at a distance R from a rectangular radiator as shown in Figure 3 is obtained by using the formulae below:

$$\phi = \frac{1}{90}\left[\frac{x}{\sqrt{1+x^2}}\tan^{-1}\left(\frac{y}{\sqrt{1+x^2}}\right) + \frac{y}{\sqrt{1+y^2}}\tan^{-1}\left(\frac{x}{\sqrt{1+y^2}}\right)\right]$$

where

x is H_r / 2R;

y is W_r / 2R;

H_r is the height of enclosing rectangle;

W_r is the width of the enclosing rectangle;

R is the radiation distance between the emitting and receiving surfaces (m).

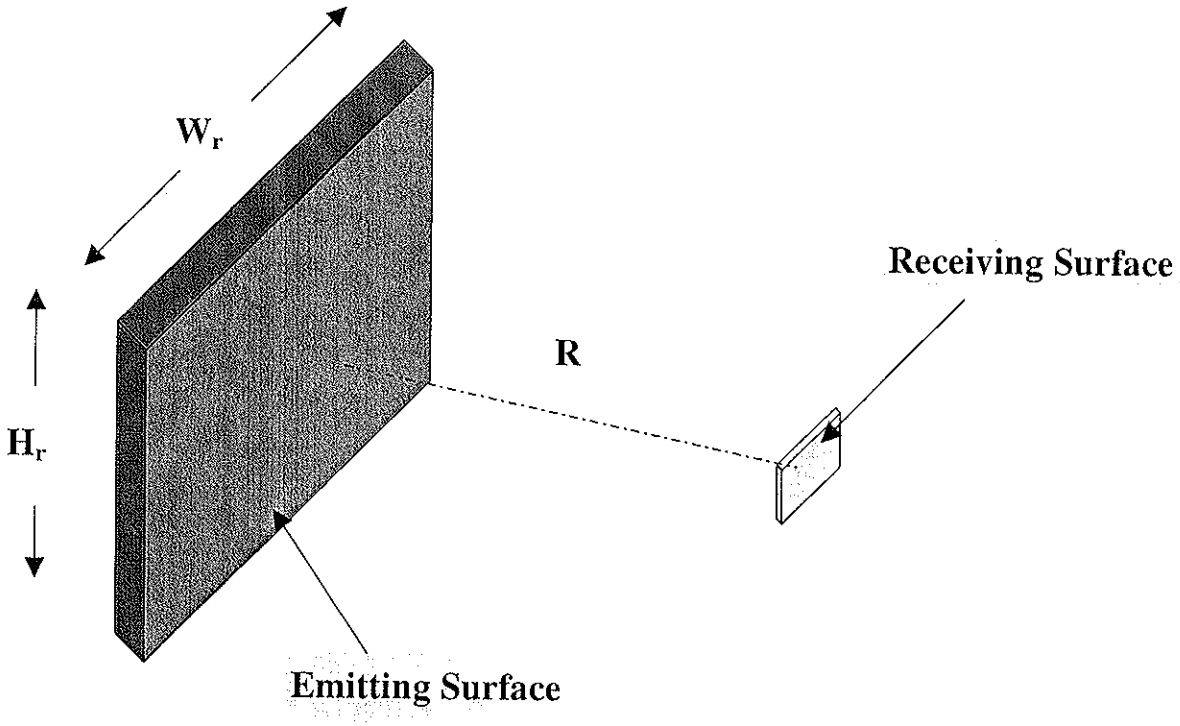


Figure 3 – Emitting and receiving surfaces from a radiation source

(g) Results

With the above methodology, a detailed analysis was carried out to quantify the radiant heat flux at 11m from building A was less than 12.6 kW/m^2 (using the worst fire scenario based on car fires at the car-park in building A). Thus, satisfying the intention of the Fire Code in preventing fire spread between two buildings due to radiation.

In this project, a redundancy analysis was also performed to analyse the effect radiant heat flux on building B in an event that sprinkler failed to operate during a fire occurring in building A. The study showed that fire would not spread from building A to building B even in the event of sprinkler failure using the same methodology as described above.

4. Case Study 2 – Natural Smoke Control System

(a) Description of building

This is the proposed addition of a 7 storey single-user warehouse at an existing godown and general store.

(b) Non-Compliance – Engineered Smoke Control System

The project cannot comply with the Clauses 7.6.7 (a) and 7.6.10 of the Fire Code 2002, which state that "smoke reservoir size for natural smoke ventilation system should not exceed 2000m^{2}" and "the maximum length of smoke reservoir should not exceed 60m".

(c) Intention of the Clauses

The first intention of these clauses is to limit the smoke reservoir size is to minimize heat loss and maintain the buoyancy of the smoke, thereby minimizing the possibility of smoke descending and thus hampering occupants during evacuation. The second intention is to facilitate fire fighters during fire fighting and rescue operations.

(d) Building Geometry

In this project, the proposed warehouse building has a gross cubical extent exceeding 113,600m^{3}. Fire safety requirements such as the compartmentation,

smoke control, etc. need to be complied with. In addition, as the warehouse is also installed with a storage racking system, appropriate sprinkler and other fire safety systems have to be complied with. Figure 4 shows a typical 3 dimensional layout of one of the warehouse floors with racking system.

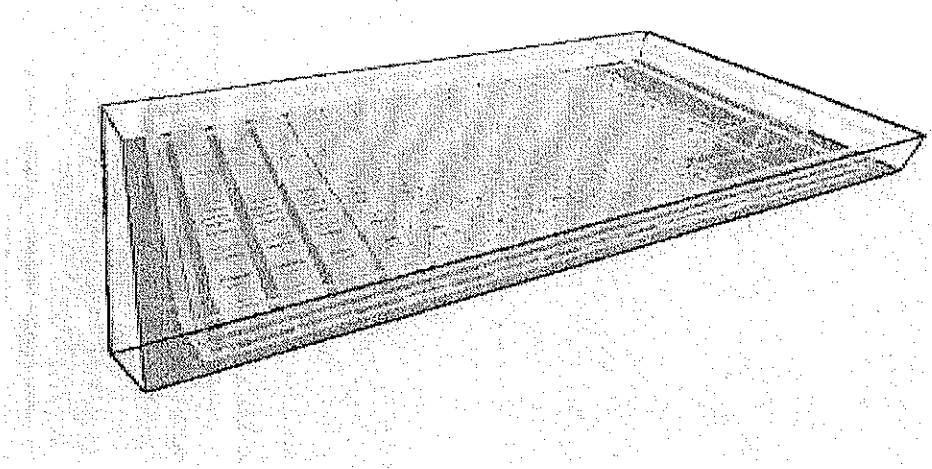


Figure 4 – 3D model of the interior of warehouse with racking system

(e) Acceptance Criteria

The FSE proposed using computational fluid dynamics (CFD) modeling to assess the effectiveness of a natural ventilation system to ventilate the warehouse floor during a fire situation. Smoke temperature (not more than 60°C for smoke layer less than 2.5m), radiation (less than 2.5kW/m^2 or 200°C for smoke layer above 2.5m) and visibility (not less than 10m) were the acceptance criteria used in the fire engineering analysis to determine the effects of fire on the life safety of occupants.

(f) Methodology

The methodology employed by the FSE was to compare Available Safe Egress Time (ASET) with Required Safe Egress Time (RSET). ASET is the time available for occupants to evacuate from a building before untenable conditions are reached. The untenable conditions are those that exceed the acceptance

criteria and they can be obtained through the use of fire modeling or manual calculations. In this project, CFD fire modeling was used. The ASET obtained is then compared with RSET, which is the time required by the occupants to evacuate a building. Evacuation modeling or manual calculations may be used to obtain this time. In this project, manual calculation was used.

If the engineering analysis shows that ASET is twice that of RSET (ASET > 2 RSET), it means that occupants can evacuate safely from the building before untenable conditions are reached. The warehouse was also modeled as accurately as possible using CFD modeling in terms of its layout, interior finishes, natural ventings, etc. The output files in terms of temperature and visibility were also specified so that the CFD could present the results after numerical simulation.

Figures 5 and 6 show temperature and visibility profiles in the warehouse, derived from the CFD package.

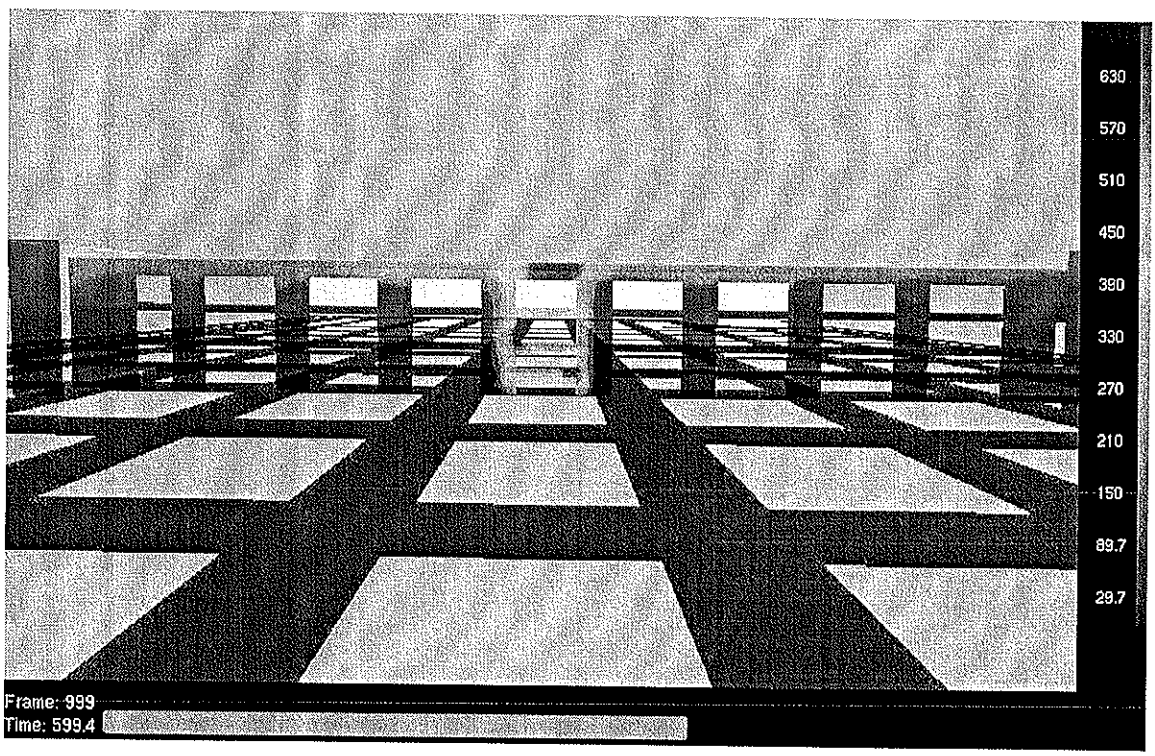


Figure 5 – Temperature profile at 600s

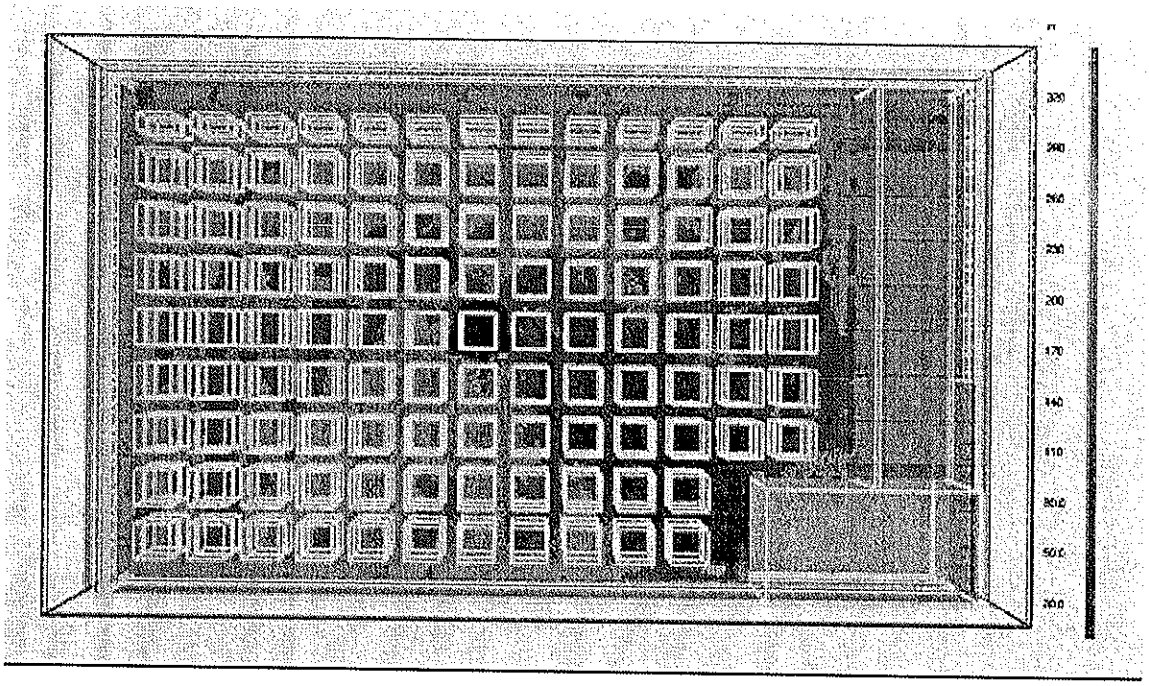


Figure 6 – Visibility profile at 600s

(g) Results

The result showed that ASET > 2 RSET. The time taken for the natural ventilation system to vent the heat and smoke generated in the warehouse was sufficiently long to allow occupants to evacuate safely. With this engineering study, SCDF had granted the waiver to exceed the smoke reservoir size and maximum length of the smoke reservoir of 2000m^2 and 60m respectively.

RELEVANT CODES & STANDARDS

5. The relevant codes, standards, sources, methodologies and data used in the performance-based designs should be based on technical references that are widely accepted and used by the appropriate professions and professional groups. Acceptance of references is often based on documents that are developed, reviewed, and validated by one of the following processes:

(a) Codes and standards that are developed through an open consensus process conducted by recognized professional institutions, code-drafting organizations, or government bodies;

(b) Technical references that are subjected to a peer review process and published in widely recognized journals, conference reports, or other publications; and

(c) Resources publications, such as The SFPE Handbook of Fire Protection Engineering, that is widely recognized technical sources of information.

6. **Annex A** lists the some of the more common standards and guidelines, which may be referenced for performance-based design.

CONCLUSION

7. To conclude, performance-based fire engineering design provides a useful alternative means of achieving efficient and effective fire safety in buildings. Now we have the means to simulate building designs using CFD analysis to detect anomalies and fix the defects virtually. With the 2 case studies highlighted, I hope they provide you with an appreciation of the applicability and usefulness of fire safety engineering concepts and tools.

Prepared By : **CPT NG KOK LEONG**
Performance-Based Plan Verification Section
Fire Safety Consultation Branch, FSSD

Annex A

List of Relevant Codes and Standards for Referencing in Performance-Based Fire Safety Engineering Assessment/Design

Codes

(1) ABCB, 1996. Building Code of Australia. Australian Building Codes Board, Sydney, Australia.

(2) BIA 1992. New Zealand Building Code Handbook and Approved Documents. Building Industry Authority, Wellington.

Standards and Guidelines

(3) FCRC, 1997. Fire Engineering Guidelines. Fire Code Reform Centre Ltd, Sydney, Australia.

(4) ABCB, 2001. Fire Safety Engineering Guidelines. Australian Building Codes Board, Sydney, Australia.

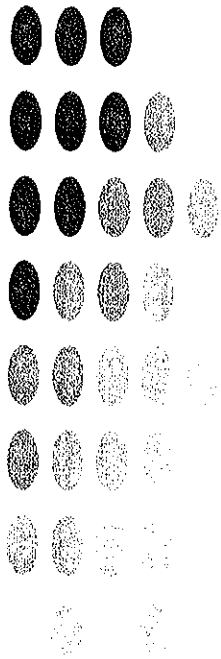
(5) Buchanan, A H, 2001. Fire Engineering Design Guide. Centre For Advance Engineering of University Of Canterbury, Christchurch, New Zealand.

(6) SFPE, 2002. SFPE Engineering Guide to Performance-Based Fire Protection. National Fire Protection Association, USA.

(7) SFPE, 2002. The SFPE Handbook of Fire Protection Engineering. Third Edition, Society of Fire Protection Engineers, USA.

Fire Safety Guidelines For General Warehouse





By

Cpt. Han Fook Kuang

Head, Industrial Section

Fire Safety & Consultation Branch

Fire Safety & Shelter Department

PROPOSED REVISION TO FIRE SAFETY REQUIREMENTS FOR WAREHOUSES

INTRODUCTION

Singapore is positioning itself to be an international logistics hub. In working towards this goal, the Singapore Civil Defence Force is reviewing its fire safety requirements for warehousing functions to meet the evolving needs in this sector of the industry.

2 Today's warehousing requires expansive and inter-connected storage spaces, which presents an entirely different set of fire risks from the general warehousing requirements a decade ago. The key driving force is the need to control fast spreading fires from the high piled storage risks involved in such high density warehousing. Although passive fire protection measures may confine the fire to area of origin, an active fire protection system may limit fire growth therefore permitting large warehouse spaces. In the area of active fire protection, automatic sprinkler systems have been shown to provide reliable and effective protection of property, while enhancing life safety at the same time. Sprinkler technology has also improved over time, with new products such as ESFR sprinklers being introduced along the way.

3 Over the years, SCDF has continually improved on its operational capabilities in mitigating major incidents, which we can leverage on in reviewing our present requirements on warehousing.

4 Based on the above considerations, it is timely therefore to revamp our present requirements to cater for today's warehousing needs.

SCOPE OF REVIEW

5 The present mega-warehouse requirements will be reviewed, based on industry feedback calling for warehouses with larger footprint and cubical extent beyond that stipulated in the existing guidelines. The terminology "mega-warehouse" will be removed to eliminate any perceived ambiguity.

CONSIDERATIONS

Classification of Warehousing Risks

6 Table 3.2A in the Code of Practice for Fire Precautions in Buildings 2002 spells out the size limitation for a building and its compartments, beyond which sprinkler provision is necessitated.

7 In applying Table 3.2A requirements to high hazard occupancies, the quoted limits in the table are halved, taking into consideration the much higher fire risks posed by high density storage or activities.

8 Currently, there is no distinction made between normal building occupancies with typical hazard storage, eg offices, classroom and the like, and warehouses storing large amount of combustibles which are non-high hazard materials, although it is clear that the latter poses a much higher fire risk.

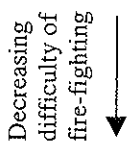
9 It is legitimate then to create a separate intermediate classification for general warehouses, between high hazard occupancy building and normal non-warehousing building. In terms of Table 3.2A figures on maximum area and cubical extent, this translates to an applied fraction more than ½ (50%) but less than 1 (100%). To cater for the uncertainty in the type of storage that can be expected for general warehouses, the proposed fraction is ¾ (75%) which is the midpoint.

Requirements based on Degree of Difficulty in Fire-Fighting Operation

10 The rationale behind the new proposed regulations stems from the underpinning factor of fire mitigation operation based on the relative difficulty posed to fire-fighting, ie faster containment of fires with decreased difficulty of fire-fighting. This is in accordance to the fire code's intention behind Table 3.2A, which is, the extent of the anticipated fire should not develop beyond the ability of the fire-fighter to control it.

11 Where limits on the area and cubical extent of Table 3.2A are exceeded, the existing code allows for the provision of automatic sprinkler systems to keep any incident fire in check, either by controlling or suppressing it altogether, such that it will still be within the means of the fire-fighter to handle.

12 Based on this principle, warehouses (apply only to sprinkler building) will be classified in ascending order dictated by the ease of fire fighting, as follows:-



(a) Multiple-storey warehouses without vehicular ramp
(b) Multiple-storey warehouses with vehicular ramp
(c) 1st storey within multiple-storey warehouse
(d) Single-storey warehouse

13 The maximum allowable sizes on area, cubical extent and the storage height will commensurate with decreasing difficulty of operational fire-fighting. SCDF expects that the new figures for limits on allowable area, cubical extent and the storage height will be able to meet the needs of most, if not all, warehousing needs without compromising on our operational capability to mitigate any fire incident.

14 From an operational standpoint, multiple-storey warehouses without heavy vehicular ramps pose the greatest relative difficulty in tackling the fire, as fire fighters will have to use the stairway and fire lift, where available. With heavy vehicular ramps, the pumpers are able to access the fire floor especially the Light Fire Attack Vehicle (LFAV). Reinforcements can be brought speedily to the incident site when required. Single-storey warehouses allow the incident commander and fire crew better control of the ground. The improved co-ordination of fire fighting efforts for single storey warehouses, in comparison with multiple-storey, provides SCDF leeway to allow for more relaxation on area, cubical extent and the storage height limits.

PROPOSED CHANGES TO THE FIRE SAFETY REQUIREMENTS

15 In the new proposed guidelines, only the term 'general warehouses' will be adopted for all such buildings designed for the purpose of storing non-high hazardous materials (goods that are not classified under SS286).

Fire Compartment Size

16 A new set of compartment size limit is proposed as stipulated in Table A1 to A3 of Annex A (Proposed Guidelines for General Warehouse) based on the complexity of a building that pose different level of difficulty to our fire-fighting operation. For sprinkler protected building without basement , only the maximum floor area together with the storage height limit are factors for determining requirements and the cubical extent is no more a criteria (except for non-sprinkler building and all the basement floors).

Use of Fire-Rated Roller Shutters to meet Compartmentation Requirements

17 Fire-rated roller shutters act as a secondary form of limiting fire spread in the unlikely event of total sprinkler failure or the inability of sprinkler action to curb fire growth. Fires in non-sprinkler protected premises can grow rapidly without any means of fire suppression thus rendering fire-rated roller shutters ineffective. Therefore fire-rated roller shutters will not be permitted for use in non-sprinkler-protected warehouses to compartmentalise the space stipulated in Table A1 to A3.

18 In other words, fire-rated roller shutters is only allowed for fire compartmentation in sprinkler-protected warehouses. Please note that this restriction does not apply to internal access door openings between fire compartmented spaces.

Fireman Access Platform with Door Access (FAPD)

19 The fireman access platform, with accompanying cat ladder, will no longer required as a necessary feature for fire fighting purpose.

Fire Extinguishers

20 Provision of fire extinguishers for industrial premises, which includes warehouses, is deemed to be adequately addressed by CP55. As such, the existing requirement for 50kg ABC dry powder extinguisher with 15m hose will no longer apply.

Automatic Smoke Vents and Engineered Smoke Control Systems

21 Smoke removal from the fire compartment allows better visual appreciation and tackling of the fire by fire fighters, and allows for faster location of deep seated fires where the warehouse footprint is extensive. It also serves to remove heat from the upper hot smoke layer, thereby reducing radiant heat reflecting downwards which could accelerate fire growth.

22 Regardless of sprinkler provision, smoke vents will be required for all warehouses below a certain area quantum, beyond which engineered smoke control systems becomes mandatory. If the provision of smoke vent is unable to meet the specified criteria as stipulated in the new guidelines then a proper engineered smoke control system shall be adopted and apply.

Emergency Voice Communication System

23 Voice communication permits better co-ordination of fire-fighting efforts within the building.

24 The present Fire Code 2002 requirement on emergency voice communication for warehouses with gross floor area more than 5,000 m^2 or habitable height more than 24 m is still applicable.

CONCLUSION

25 SCDF is making every effort to anticipate and meet today's warehousing needs and in the process fulfil Singapore's vision to be an international logistics hub. We hope that the coming changes will propel our industry towards that direction.

Prepared by : CPT Han Fook Kuang
Head Industrial Section
Fire Safety Consultation Branch, FSSD

Proposed Guidelines for General Warehouse

1 Compartment Size

Table A1 - Multiple Storey

	Maximum Fire Compartmentation Size (Max. Storage Height)	With Sprinkler Protection	Without Sprinkler Protection
Above Ground	Cubical Extent (Storage Height)	NA (15m)	12,000 m^3 (12m)
	Floor Area	6,000 m^2	3,000 m^2
Basement	Cubical Extent (Storage Height)	12,000 m^3 (12m)	Not allow
	Floor Area	3,000 m^2	Not allow

Table A2 - Multiple Storey with open-sided vehicular ramp with provision of dry riser

	Maximum Fire Compartmentation Size (Max. Storage Height)	With Sprinkler Protection	Without Sprinkler Protection
Above Ground	Cubical Extent (Storage Height)	NA (15m)	12,000 m^3 (12m)
	Floor Area	9,000 m^2	3,000 m^2
Basement	Cubical Extent (Storage Height)	12,000 m^3 (12m)	Not allow
	Floor Area	3,000 m^2	Not allow

Table A3 - Single Storey & 1st Storey Within Multiple Storey

	Maximum Fire Compartmentation Size (Max. Storage Height)	With Sprinkler Protection	Without Sprinkler Protection
Above Ground	Cubical Extent (Storage Height)	NA (18m for single storey) (15m for 1st storey)	12,000 m^3 (12m)
	Floor Area	12,000 m^2	3,000 m^2
Basement	Cubical Extent (Storage Height0	12,000 m^3 (12m)	Not allow
	Floor Area	3,000 m^2	Not allow

Note: (NA: Not Applicable)
For warehouse building with sprinkler protection system, it is allow to use fire rated roller shutters to form the fire compartmentation to conform the size limit.

2 Smoke Control System

			Type of Smoke control System
Above Ground	Individual Fire Compartmentation Size	< 100 m^2 (store room)	NA
		< 3,000 m^2	*Smoke Vent (NS)
		> 3,000 m^2	*Smoke Vent (S)
		> 5,000 m^2	Engineered Smoke Control (S)
Basement	Entire Footprint Area	< 1,900 m^2	Smoke Vent (S)
		> 1,900 m^2	Engineered Smoke Control System(S)

S : Sprinkler protection
NS : No Sprinkler protection

*Smoke vent for above ground shall comply with the following;

a) Size of smoke vent shall be minimum of 2.5% of the floor area with minimum 400mm in length and 600mm in height (for void will be 400mm x 600mm);

b) Any point within the floor area shall not be more than 12 m from any vertical opening or horizontal void opening.

c) Those required smoke vents as stipulated under cl 4.2.3(f)(iv) can be replaced by such smoke vent but to comply with the FAP size.

d) All opening shall be at highest level of the fire compartment unless it is due to the cross-beams obstruction.

Revised Technical Guidelines for Class '0' Petroleum Multi-Cylinder Installation

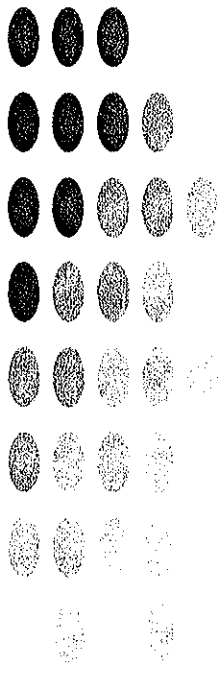
By

Lta. Aidil Arshad

Plans Audit Officer, Industrial Section

Fire Safety & Consultation Branch

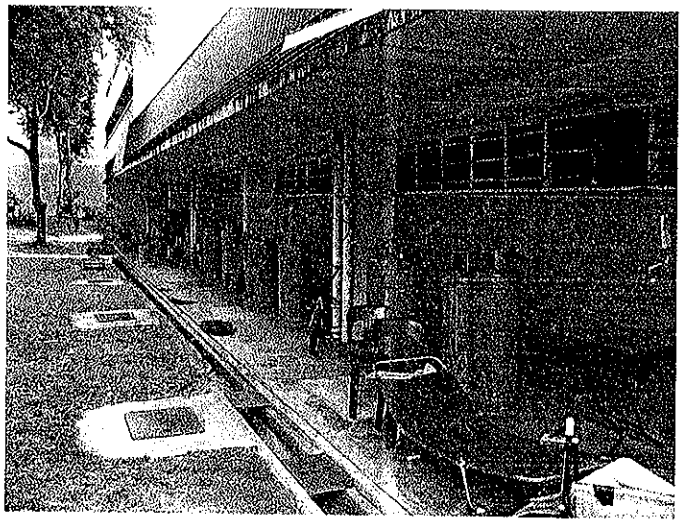
Fire Safety & Shelter Department



REVISED TECHNICAL GUIDELINES FOR CLASS 'O' PETROLEUM MULTI-CYLINDER INSTALLATION

INTRODUCTION

Liquid Petroleum Gas (LPG) is popular as a fuel for cooking in food outlets. Being flammable, it poses a fire and health risk if the LPG cylinders are not properly installed. Furthermore, LPG installations if kept outside were also prone to vandalism. (See Figure 1). In July 1989, the storage and installation of LPG were regularized based on the internal Technical Note, 'Cylinder/Cartridge Storage and Installation of Class "O" Petroleum'.



(Figure 1)

2. In September 1993, the LPG manifold system was introduced. The strategy was to have the LPG piped in from LPG cylinders, housed in a properly ventilated and protected metal enclosure, stored outside the building. It was then agreed by LPG suppliers, HDB, Town Councils and FSSD that a centralized LPG manifold system, though more costly to install is safer. This arrangement would also provide a constant supply of LPG to the users.

3. Effective from December 1997, all owners of premises using LPG are required to obtain a license for LPG storage and installation and to comply with FSSD requirements. A set of internal guidelines for LPG manifold system was developed based on NFPA 58, NFPA 54 and SS 233 to regulate this. However, this set of guidelines was not circulated or published in the Fire Code. The SCDF has since revised the guidelines to consolidate and regularize all previous technical notes and guidelines developed. This revision is applicable to new LPG installations or any other related additional or alteration works for both indoors, outdoor and other non-domestic installations. This paper will address the revised guidelines. It will also highlight the bad practices in LPG storage and usage at the various premises eg. Coffee-shops, restaurants, hawker centers and other commercial outlets

SPECIAL CONSIDERATIONS GOVERNING LPG INSTALLATIONS

4. Special considerations are given to LPG installations under the following situations:

a. Fire protection for LPG installation within exempted quantity.

Under the Fire Safety Act 2001, LPG within the specified exempted quantity does not require a license for storage. However, there are instances where LPG within exempted quantities are being piped into the building through manifold systems. Under such circumstances, a formal submission by a QP is required to certify and supervise the installation.

b. Requirements for non-domestic installations.

In situations where the LPG installations could not meet the requirements for outdoor or indoor installations specified in the revised Technical Guidelines, LPG cylinders within a recess on the external side of a building could be allowed.

PROBLEMS AND BAD PRACTICES FOUND AT SITE

5. Due to the pervasiveness of LPG cylinders for cooking and its associated risks, SCDF conducted site inspections to deal with the matter. The usage of LPG cylinders used for cooking purposes in commercial buildings creates fire risks or hazards arising from improper storage, close proximity to heat or combustible material, poor house keeping, leakage of rubber hose and mishandling, etc.

No Gas Detection and Exhaust System

6. There were cases of liquid LPG being piped into buildings which has no gas leakage detection system or interconnection to the exhaust fan system. This could lead to a flash fire or even a vapour cloud explosion if there is a leakage within a confined space. Having LPG cylinders located at various location within such buildings would cause more complications in locating and mitigating the source of the leak.

No Control on Quantity Used

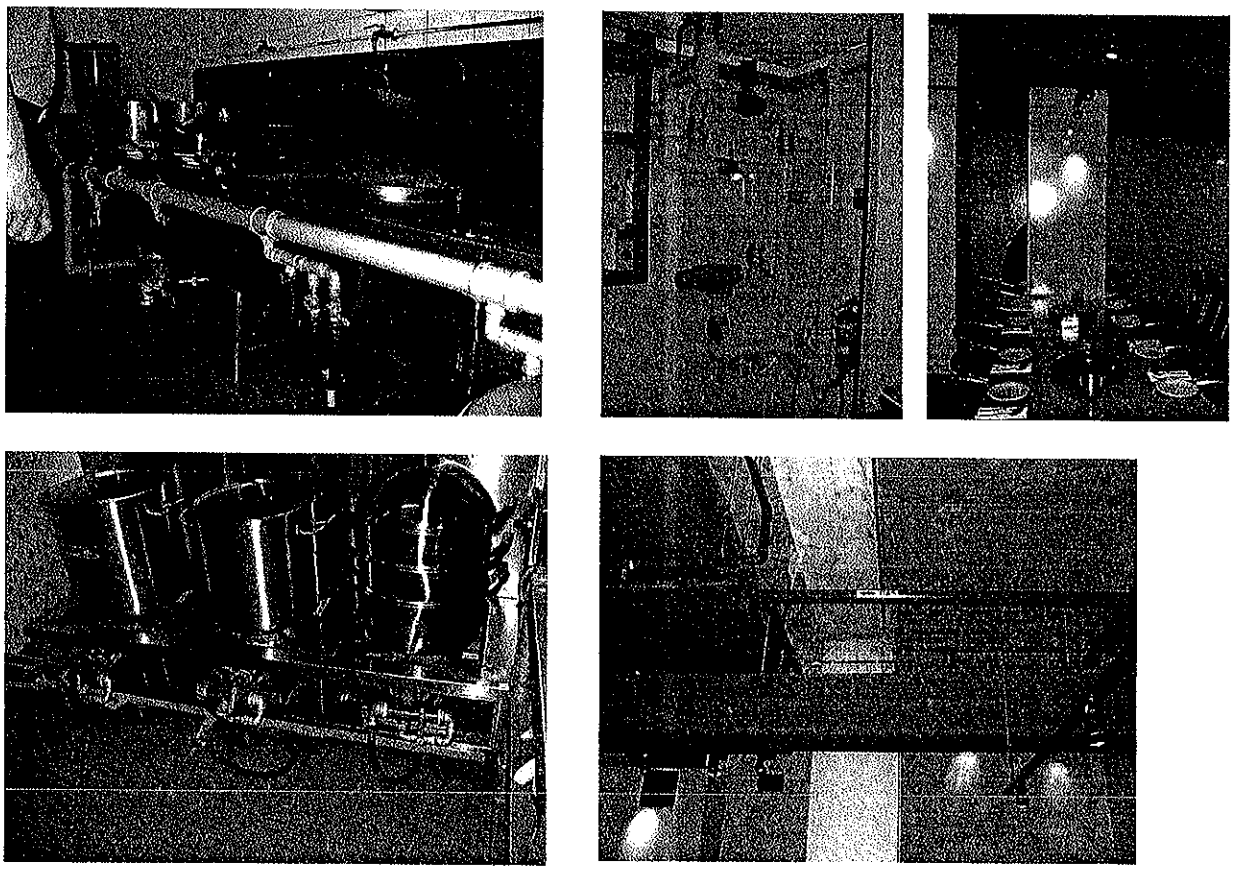
7. Site inspections carried out to old commercial buildings also revealed that there is no control on the quantity used. In one shopping centre at orchard road, there are currently a total of 48 restaurants operating on the 4th and 5th storey in that building. Out of this 48 units, 10 of them are using town gas and the rest have LPG cylinders being installed in their kitchens. It was further established that the average quantity of LPG cylinders used by one kitchen at any one time is 3 units, therefore making it a total of 1710 kg of LPG (38 units X 3 cylinders X 15kg). There is no control on the number of cylinders allowed in the building.

Non Compliance with Fire Code

8. There is no fire safety measures provided in terms of separation distance, ignition source, compartment etc. The eating outlets are separated by a common partition wall and a common corridor. The eating outlets are not compartmented from other usages in the building. This is in violation of Clause 3.2.5 (f) of the Fire Code. Kitchen hood and ducts serve each eating outlet. The LPG quantity for each eating outlet was found to be 45kg which exceeded the permissible quantity of 30 kg for the category of food stalls under the Fire Safety Act. The LPG quantity for the whole eating place in the entire building was found to be 1710kg in total. This figure exceeded the 210kg for the eating place stated in the Fire Safety Act. Even though this figure is below that for restaurants which is 200kg per kitchen, there is no proper separation between the kitchen and the rest of the building.

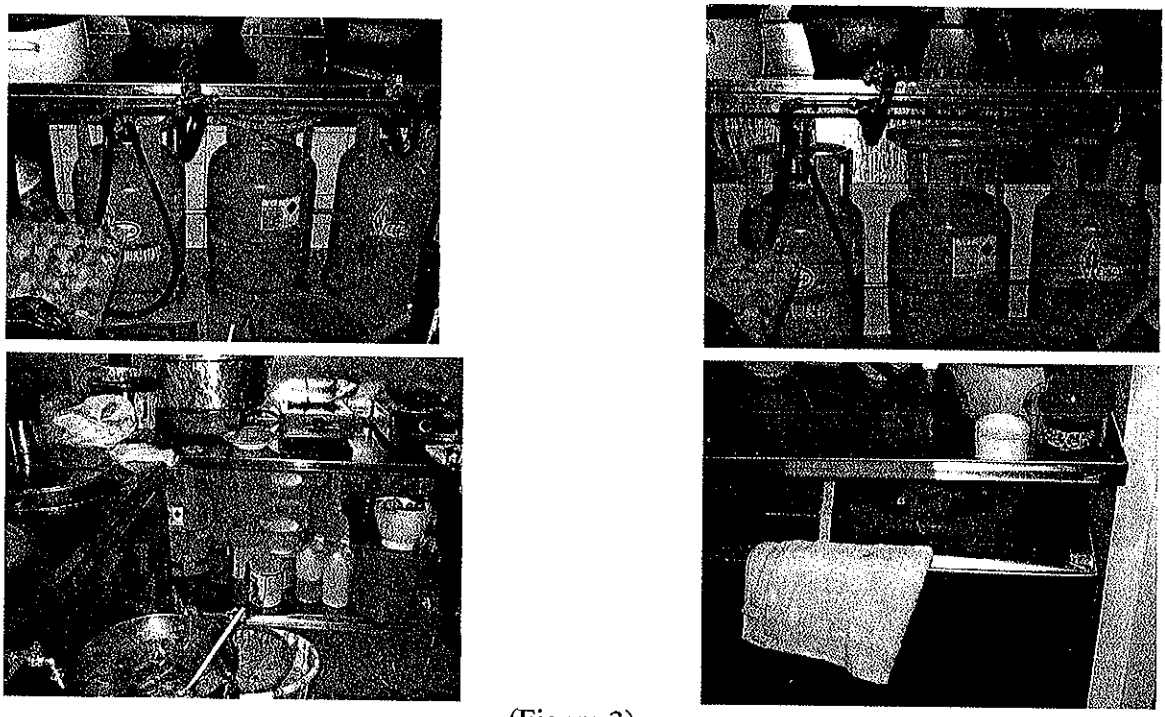
Tenancy / Multiple owner arrangement

9. In the case of building managed under sole proprietorship where LPG installations are used, they are found to have proper fire safety features incorporated. However, this is not the case for multiple ownership buildings. Eating outlets in such buildings have individual LPG cylinders installed within the cooking area without proper fire safety measures. Figure 2 shows the usage of town gas by newer commercials establishments and buildings.



(Figure 2)

10. The building management also faces the dilemma in relocating all the eating places on the upper floors to the ground floor to cater for the restaurants using LPG cylinders during the interim period for renovation as mentioned above. However, this would raise queries as to why the restaurants were allowed to use LPG cylinders on the 4th and 5th floor in the first instance. If this nature of installation is allowed or included in the Fire Code, future plan submissions would definitely have proposals of restaurants or eating outlets on the higher floors with LPG cylinder installations. Therefore, some means of fire safety requirements need to be imposed for this category of installations. See Figure 3 for such cases.

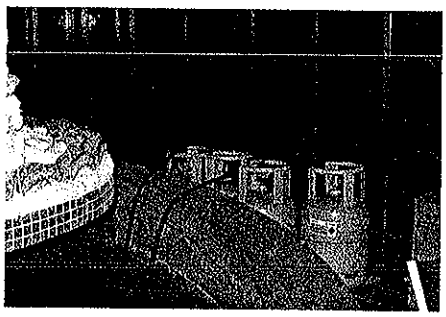


(Figure 3)

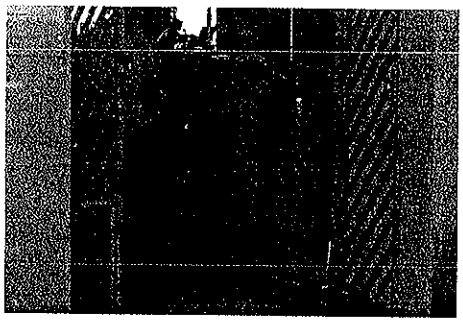
PROPOSED REVISIONS TO THE FIRE SAFETY GUIDELINES FOR LPG INSTALLATIONS

LPG Installation within Exempted Quantity

11. The Fire Safety Act (2001) stipulates that LPG cylinders within the exempted quantity need not require a license for storage. However, installation methods and fire safety requirements for this LPG group are not mentioned or developed with the implementation of the manifold system. However, through site surveys conducted in August and early September 2003, it was found that LPG cylinders within exempted quantity at food stalls and restaurants do not have sufficient fire protection within the building (see Figures 4 and 5).



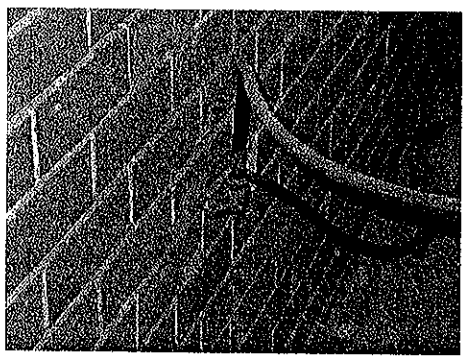
(Figure 4)



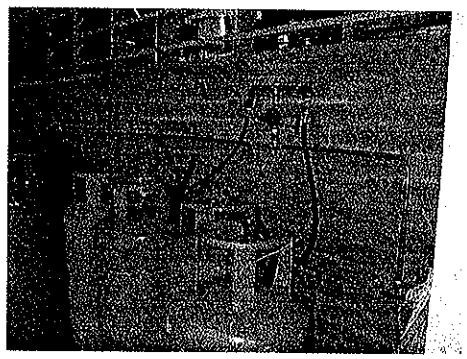
(Figure 5)

12. Making reference to Clause 3-2.2.1 of NFPA 58, it was stated that LPG containers shall be located outside buildings with an exemption that containers of less than 200kg are allowed to be installed in buildings provided that the structures comply with Clause 7.2 of NFPA 58. It also clearly states that structures intending to hold LPG cylinders within the exempted quantity (maximum 200kg) must be one storey in height and located at the ground floor.

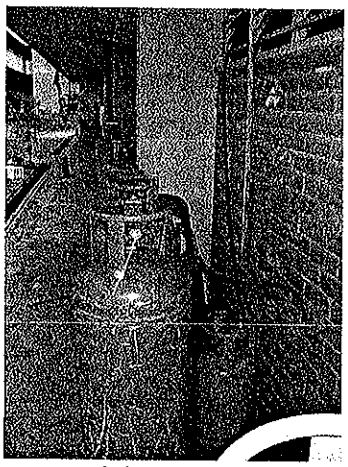
13. Figures 6 to 10 further justified the need for fire protection measures. It could be seen that even though LPG is used within the exempted quantity, fire hazards do exist due to the lack of fire safety measures. Figure 6 shows the lack of a fire stopping device or sealing of the wall. The gas, smoke or even fire can spread through the opening. Figure 7 shows that no proper fire rated wall is provided adjacent to the LPG cylinders. Fire and smoke could spread through the opening above the cylinders. Figure 8 shows that there is no proper enclosure or protection against exposures (empty or neighboring tanks at site) or vandalism. Figure 9 shows that there is no proper piping system for the LPG installation. Every cylinder has it's own opening in the wall. This would make shutting off the main supply difficult in an event of fire. Fire fighters might need to shut off individual tanks if there is no one emergency shut off valve to a common piping system. The installation method for the exempted quantity should be similar to the manifold system, incorporating a metal cabinet and the piping system complying with NFPA 58 and other approved standards. The cylinders should be in an enclosed metal cabinet with proper piping system. The proposed configuration is shown in Figure 10.



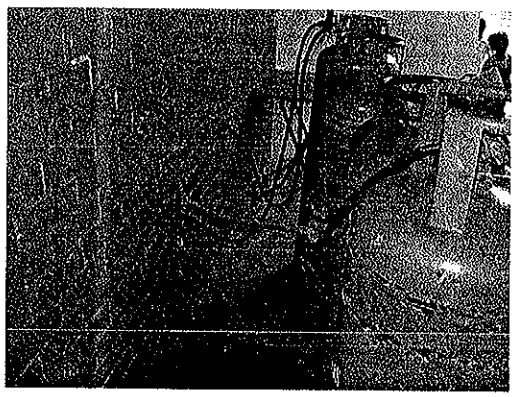
(Figure 6)



(Figure 7)



(Figure 8)



(Figure 9)



(Figure 10)

Licensing Requirements for Outdoor Installations

14. Outdoor LPG installations are sometimes located in close proximity to drains, pits or manhole. LPG being heavier than air would sink to the ground and might enter into these below ground accesses which could lead to a flash fire when there is a source of ignition nearby. There are two situations in which these could happen. Migrant LPG vapors could sink into trapped drains, pits or manholes. Trapped drains are normally shallow in depth used to channel water to a deeper sewerage. The LPG would not be able to accumulate or reach the flammable limit for ignition as the trapped drains are too shallow to allow this to happen. Furthermore, the ventilation and air circulation would be more than enough to disperse the vapor if any. In such a case, cylinders must be at least 1.5 meters from any trapped drain. For un-trap drains, pits, manhole or other underground openings, the distance must be at least 2 meters from the nearest edge of the LPG installation. This would also include openings into cellars or basement. Measures must be taken to prevent LPG from entering these openings when there is a leakage.

15. A majority of the coffee shops using LPG were found to be situated near to the car parking lots, especially in the HDB blocks. The distance between the LPG installation to the nearest edge of the parking lot must be at least 1.5 meters. Cylinders shall also not be located within 3 meters of any fire exit from a building. Submissions made for multi-cylinder installations can sometimes reach to a maximum number of 20 cylinders (10 cylinders per cabinet). Some eating houses or coffee shops do require more LPG cylinders to operate. But this value must be restricted to a maximum of 1000kg by weight. Therefore for quantity of LPG cylinders exceeding 600kg in weight should be imposed. These requirements include 2 hours fire rated wall barrier between the two groups, 5 meters from any boundary and that the cylinders must be at least 1 meter away from the firewall. See Annex A for detailed arrangements.

Licensing Requirements for Indoor Installations

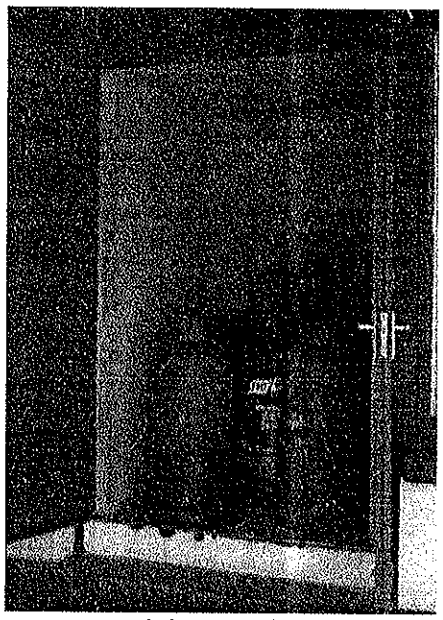
16. Attempts must first be made to locate the cylinders outdoors. Installation of LPG cylinders indoors is only allowed if it is impractical to be installed outdoors. Indoor installations are only permitted at the ground floor with the appropriate level of fire protection, be it outdoors or indoors installations. This requirement is similar to other overseas codes and standards such as NFPA, Irish LPG Standard, Hong Kong LPG Code, UK LP Gas Association Code of Practice and other related issues.

17. A maximum quantity of 400 kg by weight of LPG is allowed in a single manifold. Installation shall be in a separate compartment of 2 hours fire resistance rating. This requirement is in the current internal Technical Note and will be incorporated into the revised Technical Guidelines.

Other Requirements for Non-Domestic Installations

18. There might be situations whereby there would not be ample space or location to install the LPG cylinders next to a building. Another means to locate the cylinders could be provided by having a recess area on the side of a building with the appropriate fire protection measures. Only a maximum of 8 x 50kg cylinders is permitted in such areas.

19. The installation must of course be at the ground level with a recess made of 2-hour fire rating wall. The recess must also be kept to a minimum distance of 1 meter deep. Any pipe penetration must be suitably fire stopped with 2 hours fire resistance. Ventilation must be permanent and unobstructed. A minimum distance of 3 meters must be kept from any fire exit from a building and suitable access to the cylinders must be provided for fire emergency services. The building must be sprinkler protected. See illustration 11



(Figure 11)

CONCLUSION

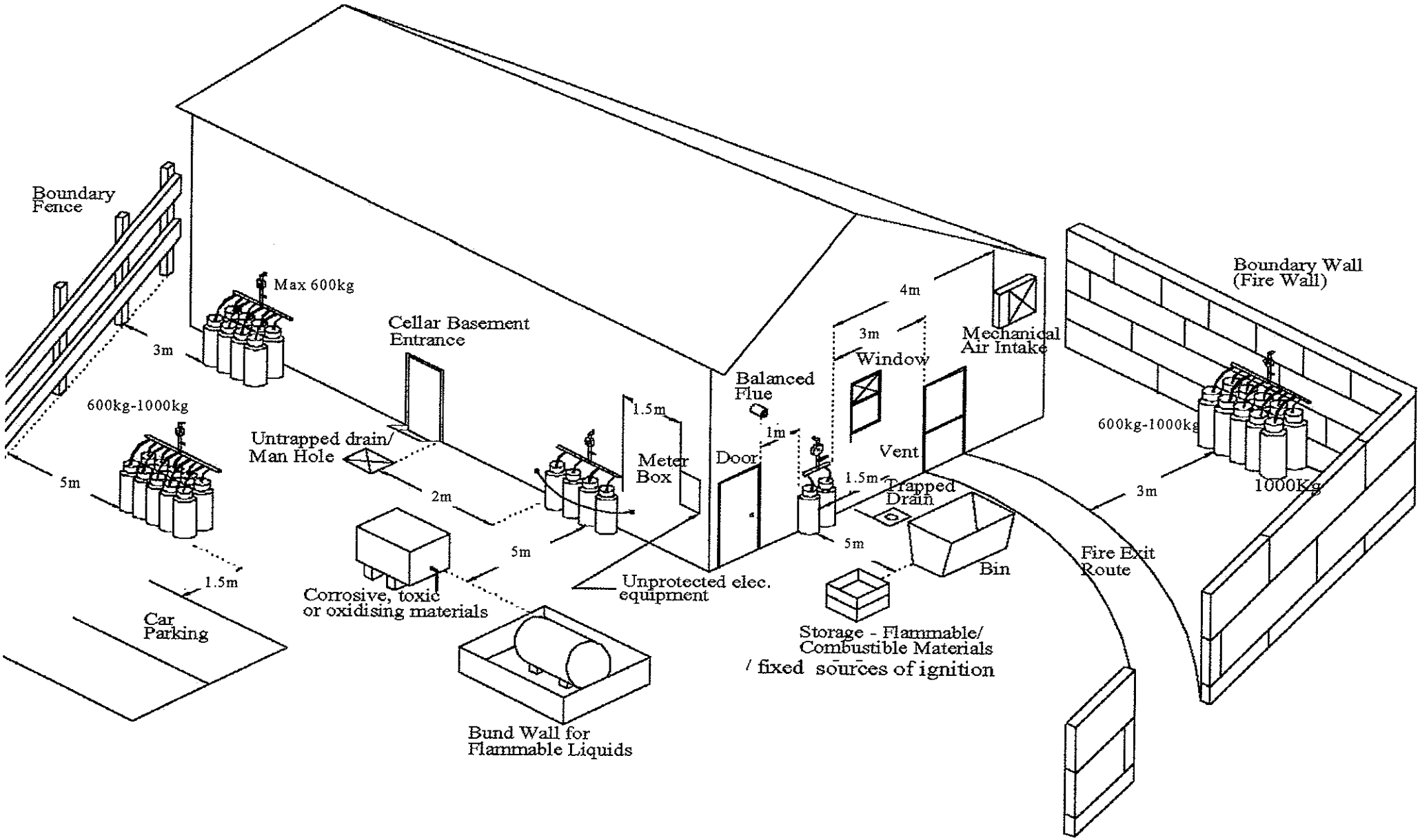
20. LPG is a popular fuel source for use in cooking in food outlets and eating establishments. LPG is being supplied to such premises either indoors or outdoors by various means eg bottled cylinders or fixed installations. Arising from the onsite inspections conducted at these outlets, bad practices prevail posing a fire risk to the food operator and neighbouring units and customers. A revision to the existing technical guidelines to regulate fire safety in LPG installation and storage is necessary. It will be incorporated into the next revision of the Fire Code for use by Qualified Persons and those in the LPG trade.

Prepared By: Lta Aidil Arshad
Plans Audit Officer
FSSD / SCDF

REFERENCES

1) NFPA 58 Liquefied Petroleum Gas Code – 1998 Edition
2) NFPA 54 National Fuel Gas Code – 1999 Edition
3) Irish LPG Standards – 2002 Edition
4) Hong Kong LPG Code – 2000 Edition
5) UK LP Gas Association Code of Practice 2002 Edition.

ANNEX A


Boundary Fence
Max 600kg
3m
Cellar Basement Entrance
600kg-1000kg
5m
1.5m
Car Parking
Untrapped drain/ Man Hole
2m
5m
Corrosive, toxic or oxidising materials
Bund Wall for Flammable Liquids
1.5m
Meter Box
Balanced Flue
1m
Door
Unprotected elec. equipment
4m
3m
Window
Mechanical Air Intake
Vent
1.5m
Trapped Drain
5m
Bin
Storage - Flammable/ Combustible Materials / fixed sources of ignition
Fire Exit Route
Boundary Wall (Fire Wall)
600kg-1000kg
3m
1000Kg

New Control Measures For Petrol Service Stations

By

Cpt. Winson Cheung

Head, Enforcement & Licensing Section

Certification & Enforcement Branch

Fire Safety & Shelter Department

NEW CONTROL MEASURES FOR PETROL SERVICE STATIONS

INTRODUCTION

Presently, in Singapore, there are a total of 222 petrol service stations located all over the island. Arising from the increased tension and stepped up security after the 11 September incident at World Trade Centre, USA and the Bali bomb blasts, concerns had been raised about the vulnerability of petrol service stations, in particular that terrorist attacks could possibly involve petrol service stations and petrol tankers, either on the roads or more specifically at petrol service stations.

2 Before, the main concerns on fire safety of petrol service stations are on minor spillages, incipient fires, and proper usage of the premises. The existing protection of ancillary/associated fire safety measures would be adequate to limit damages should an accidental mishap takes place. Now, the main concerns include the possibility of catastrophic incidents such as explosions, security threat implications and vulnerability of off-site exposures. Any incidents that may arise from terrorist attack to the petrol service stations could cause catastrophic damage to property and loss of lives. New control measures were thus introduced in the petrol service stations to minimise the risks of such threats in view of the current heightened security environment.

NEW SECURITY THREATS AND RISKS

3 The planning norms for siting petrol service stations are based on three factors, namely the degree of pollution, traffic considerations and optimization of land use. From the fire safety perspective, fuels in petrol service stations are stored in underground tanks and these tanks are individually enclosed in sand-filled, reinforced concrete or brick chambers. As such, the risks of fires from fuel tanks in the petrol service stations are minimal. However, in the current security climate, it can still pose a risk from being sabotaged if the manholes or access pits to the tanks are left unguarded or unsecured.

4 As many of the petrol service stations in Singapore are situated at populated areas near housing estates, any risk associated with the petrol service stations cannot be taken lightly as the impact on the population could be serious in event of an incident. As the petrol service stations are very open areas which are highly accessible by motorists and public. It is thus essential that the physical safety of petrol service stations must be enhanced through improved surveillance and security. The threat can also come from the associated transportation of bulk fuel tankers that replenish the underground tanks of the petrol service station on a regular basis; as these could offer potential perpetrators convenient and ready devices which could be exploited as a weapon of terror.

5 In view of the above, security control measures for all the 222 petrol service stations have been put in place to prevent and deter possible occurrences that may arise from any terrorist attack.

IMPLEMENTATION OF NEW CONTROL MEASURES

6 Since early of 2003, SCDF had held a series of dialogue sessions and meetings with the security authorities and the major oil companies, to discuss the introduction of control measures at all petrol service stations. Through these sessions, a set of control measures were developed and agreed upon for implementation so as to enhance the safety and security measures of all the petrol service stations. The regulatory control of the petrol service stations was made effective on 1 Sep 2003 with the incorporation of the amendments to the Fire Safety (Petroleum) Regulations.

7 The control measures which had been introduced and implemented are as follows:-

(a) **Licensing of petrol storage in petrol stations**

(1) The Licensing of petrol service station was made effective on 1 Sep 2003. The Licensing requirements and new control measures for petrol service stations were incorporated into the Fire Safety (Petroleum) Regulations. It is mandatory for the petrol service stations to comply with the fire safety requirements as well as the new security control measures.

(2) To date, the licensing of the 222 petrol service stations has been effected and inspections to check on the required measures in the respective petrol service stations have been completed. Regular and surprise checks on the petrol service stations to ensure compliance on the fire safety requirements as well as the new control measures will be continued.

(b) **Placing of barriers at petrol service stations to impede and deter against vehicles ramming into the premises and to stop pump operation and deny access during refilling operation :** The barriers in the form of permanent and removable barriers installed at the entrances and exits of the petrol service stations are meant to impede and deter the threat of a vehicle used by perpetrators to carry explosives to ram into the petrol service station to cause damage. However, the placing of the barriers and stopping of pump operation and denying of access by motorists when petrol tankers are refilling the tanks in the petrol service stations would only be effected when the security threat level is raised. SCDF would inform the major oil companies when such time arises. Nevertheless, the barriers are already prepared and made available during normal time and be ready for installation upon activation during heightened threat level.

(c) **Denying access to the underground fuel storage tanks eg. by installing locking device :** The fuel storage tanks in the petrol service stations are currently buried deep underground in sand-filled chambers, and thus unlikely to cause ignition of the fuel or fires in the storage tanks. However the same will not be so if there is any breach to the underground tank such as if the manholes or access pits to the tanks are left unguarded or unblocked. Thus locking of the manholes or access pits has to be implemented to prevent sabotage or unauthorized access except for maintenance purpose.

(d) **Improved surveillance by using closed-circuit televisions (CCTVs) :** The installation of CCTVs will enhance the security coverage to all critical areas of the petrol service stations such as the petrol refilling points, the manhole areas, the forecourts, backcourts and dispensing areas. This measure would also complement other measures and enhance the physical surveillance within the petrol service stations so as to detect any suspicious persons or objects early; and prevent any mishaps or incidents in the petrol service stations. The CCTVs will also serve to provide evidence and aid in the post incident investigation should an incident strike in the petrol service station.

COLLABORATION WITH OIL COMPANIES

8 In the process of implementing the regulatory requirements and new control measures, close coordination has been established with the major oil companies through regular dialogues, meetings and briefings and garnering of feedback from these stakeholders. It has also ensured that the measures implemented were feasible with minimal effects/disruptions on the business operations of the petrol service stations.

9 The Standard Operating Procedures (SOP) outlining the procedures for the notification process, activation of the control measures eg erection of bollards/barriers

during refilling at all petrol service stations when situation arise; has also been put in place to ensure things are in order and that security measures be activated speedily within short span of time. Through the implementation, it has strengthened the working relationship between SCDF and the oil companies, thus fostering better co-ordination and understanding in the partnership of SCDF with the industry in ensuring a safe and secure Singapore.

CONCLUSION

10 Explosions and fires arising from sabotaged petrol service stations have the capacity to cause catastrophic damage to buildings and structures as well as high human casualties. Panic and fear amongst the population are likely psychological spin-offs. Singapore being small could not afford to have any terrorist incident happening here as just one incident would cause great damage not just to the loss of lives and property but also to the nation's security and economy as a whole. The licensing of the petrol service stations and the implementation of the new control measures serve to arrest the threats and risks faced by the petrol service stations and ensure a safe and secure environment for all.

Prepared by : CPT Winson Cheung
Head Enforcement & Licensing Section
Certification & Enforcement Branch, FSSD