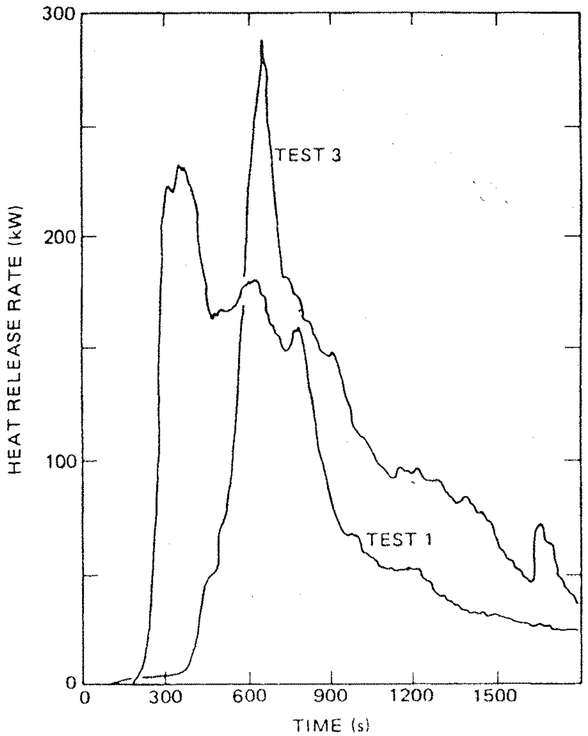
SESOC SEMINAR SERIES

The New Zealand Structural Engineering Society presents

Fire Engineering Design

Applications of the Fire Engineering Design Guide



The Fire Engineering Design Guide has been produced by a SESOC/NZFPA joint committee and is published by the Centre for Advanced Engineering, University of Canterbury

NEW ZEALAND STRUCTURAL ENGINEERING DESIGN SOCIETY

FIRE ENGINEERING DESIGN SEMINAR.

APPLICATIONS OF THE FIRE ENGINEERING DESIGN GUIDE.

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NZ Structural Engineering Society
P.O. Box 6508
Auckland, New Zealand

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INTRODUCTION

The New Zealand Structural Engineering Society welcomes participants to this, the second of the SESOC Seminar Series '94 presentations.

The purpose of the seminar series is to provide, in a practical way, information which will enable building design professionals to maintain a standard of excellence and skill in keeping with recent research and development in our respective fields. We are choosing therefore to emphasise the direct and practical approach which will be found in the worked examples appended.

The seminar is not intended to replace the "formal paper" approach, but rather to complement it by giving an interface between theory and practice.

The Management Committee of SESOC would welcome feedback from participants on the value of this approach together with any suggestions for improvements in future seminars.

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ACKNOWLEDGEMENTS AND DISCLAIMER

1. The SESOC Management Committee wishes to express its thanks to the all who have assisted in preparing the information used in the design guide.

A list of contributors is set out inside the guide itself.

2. Whilst every care has been taken in attempting to interpret the use of the guide correctly, the authors of the guide, their firms and the presenters at this seminar take no responsibility for any particular application of these interpretations. Examples do not necessarily represent full and realistic design cases. They are presented to illustrate particular aspects and should not be taken as representing solutions to general cases.

Comments On Applications Of The Building Act 1991

In fire design, particular sections of the Building Act 1991 impinge on the logical processes of design development. It is absolutely critical before commencing a fire design that the designer understands which aspects of the Act are being followed.

Typical situations are:

1.0 A Development Involving Cross-Lease Unit Title Or Strata Title

Before the Territorial Authority is able to issue a certificate of sub-division, Section 224(f) of the Resource Management Act (included on page 113 of the Building Act) requires that the proposed development comply with Section 46(4) of the Building Act.

For a new building this will require compliance in full with **means of escape from fire, protection of other people's property, and access and facilities for access and facilities for use by people disabilities (where this is a requirement in terms of Section 25 of the Disabled Persons Community Welfare Act 1975).**

For an existing building being modified compliance must be "as nearly as is reasonably practicable to the same extent as if it were a new building". The building must also continue to comply with the other provisions of the building code to at least the same extent as before the application for a sub-division affecting that building or part there of was made.

2.0 Change Of Use

Where the use of a building is being changed, Section 46(2) requires that "the use of the building shall not be changed unless the Territorial Authority is satisfied on reasonable grounds that in its new use the building will:

a) comply with the provisions of the building code for **means of escape from fire, protection of other people's property, sanitary facilities, structural and fire rating behaviour and for access and facilities for use by people disabilities (where this is a requirement in terms of Section 25 of the Disabled Persons Community Welfare Act 1975) "as nearly as is reasonably practicable to the same extent as if it were a new building"; and**

b) continue to comply with the other provisions of the building code to at least the same extent as before the change of use.

3.0 Alterations To Existing Buildings

Where a building is being altered but is continuing in the same use and is not being sub-divided then Section 38 says that "no building consent shall be granted for the alteration of an existing building unless the Territorial Authority is satisfied that after the alteration the building will:

a) comply with the provisions of the building code for **means of escape from fire and for access and facilities for use by people disabilities (where this is a requirement in terms of Section 25 of the Disabled Persons Community Welfare Act 1975), "as nearly as is reasonably practicable to the same extent as if it were a new building"; and**

b) continue to comply with the other provisions of the building code to at least the same extent as before the change of use.

4.0 Comment

It is absolutely critical that the designer establish the legal requirements before beginning the design. If there is no requirement for protecting other people's property then this must be clear in the mind of the designer before commencing the work.

5.0 Recommended Sequence

In many situations the simplest method is to evaluate the building in terms of the approved documents <u>and then to determine which parts of the solution apply</u>. This will of course not be necessary if the alteration for example is a simple one. However there are parts of clause C3 which impinge on means of escape and cannot be ignored even when the evaluation is being undertaken under the terms of Section 38, and the controlling document appears to be clause C2.

6.0 Section 34 Alternate Solution

When a clear framework has been established for the legal basis and perhaps after the approved documents have been checked to see if a simple solution might emerge then under Section 34 of the Building Act an alternative solution may be attempted.

Section 34 may be invoked when for example an advantage can be obtained in the reduction in fire ratings or in specific design by evaluating smoke layering behaviour as compared to fire growth and means of escape times - these are dealt with elsewhere in this seminar.

Note that when working under Section 34, reference must be made directly to the building code. The building code is a non-quantitative document which is nevertheless a precise instrument of law.

In preparing an alternative solution the designer must I believe address each clause in turn and at least make a comment on every provision in regard to the particular design being evaluated.

For example, this is the time to disqualify all property protection requirements if the project is simply an alteration to a building with no change of use and no sub-division of title.

7.0 Summary

The Fire Engineering Design Guide will only be useful to designers who have a clear understanding of the law and can apply specific fire engineering design in the right way and in the right place.

8.0 Case Study

Attached is an actual case study which is re-printed by permission of Health Waikato (the client) and Devine Erby Mazlin (NZ) Ltd (the architects) illustrating the above comments for an alteration in a five storey hospital block.

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PRINCIPAL: J.A. (Tony) Gibson, BE. MSc(Lond.), DIC, MIPENZ, ANZIM, Registered Engineer.

FIRE REPORT

FOR

LOBBY ALTERATIONS TO THE WAIORA CENTRE

AT

WAIKATO HOSPITAL, PEMBROKE STREET HAMILTON

FOR

DEVINE ERBY MAZLIN (NZ) LTD

June 1994
PROJECT NO: 4045

[1] Denotes professional engineers - from the word "ingenuity".

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17 June 1994

Devine Erby Mazlin (NZ) Ltd
Level 11, 8-10 Whitaker Place
AUCKLAND

Attn: Sally Smith

Dear Sally,

WAIORA WAIKATO CENTRE (SURGICAL BLOCK) FIRE REPORT

Following a request from Devine Erby Mazlin (NZ) Ltd we have undertaken an analysis of the New Zealand building code fire performance requirements for the above proposed project, comprising an upgrade of the entry lobby, as follows:

1.0 Analysis Strategy

This is an alternative solution submitted under Section 34 of the Building Act.

The most appropriate method is to undertake a full analysis as if the entire project were a new building and then to determine which parts of the results apply. The report is based on the BIA Approved Documents (Acceptable Solutions C2/AS1 and C3/AS1) in so far as is appropriate. Alternative fire engineering options have then been undertaken in respect of means of escape.

Therefore this report comprises three parts:-

a) Legal environment and building use (below).
b) Assessment against the Approved Documents (Appendix A).
c) Findings and recommendations (below).

2.0 Legal Environment

This is an "alteration" under the Building Act 1991. All new work must therefore comply fully with the New Zealand building code, whilst certain aspects of the existing building also require consideration as below.

[1] Denotes professional engineers - from the word "ingenuity".

Under Section 38 of the Building Act 1991 the following aspects of the entire building must comply with the building code "as nearly as is reasonably practicable to the same extent as if it were a new building":-

a) Means of escape from fire.
b) Access and facilities for use by people with disabilities where this is a requirement of the Disabled Persons Community Welfare Act: 1975 (this building falls within that provision under section 25(4)(k)).

This report covers the first of these only, with disabled access being handled elsewhere.

Other provisions of the building code must continue to comply to at least the same extent as before the alteration.

2.1 Building Description

The building is situated in the hospital complex in Pembroke Street, Hamilton. Construction is of reinforced concrete and the plans provided show a date of May 1965. The building is therefore nearly 30 years old.

The existing building has a fully operational heat detection system.

2.2 Building Use

As advised by Mr Kevin Bardsley, project officer for the development, the building contains no hospital wards occupied overnight but does contain situations involving unconscious patients during the day, under general anaesthetic.

2.3 Building Code Requirements

The **objective** of clause C2 (Means of Escape) of the New Zealand building code is set out in clause C2.1, to:
a) Safeguard people from injury or illness from fire whilst escaping to a safe place and
b) Facilitate fire rescue operations.

The **functional requirement** under C2.2 is that buildings shall be provided with escape routes which:
a) Give people adequate time to reach a safe place without being overcome by the effects of fire and
b) Give fire service personnel adequate time to undertake rescue operations.

The **performance** requirements of the code set out factors to be taken into account in reaching the design requirements. These include the number of open paths required being dependent on travel distance; number of occupants; fire hazards and fire safety systems within a firecell. The number of exitways or final exits must take these factors into account as well as the distance of open path travelled. Performance requirements also state that escape routes shall be of adequate size; free of obstructions; of a length appropriate to the mobility of people using them; resistant to the spread of fire; easy to find; suitably illuminated and complying with the ease and safety requirements of clause D1.3.3 on access routes.

3.0 Assessment Relative to Acceptable Solutions

For initial analysis the acceptable solutions issued by the Building Industry Authority provide a suitable framework for assessing existing performance. Analysis of the building using these solutions is undertaken in Appendix A. Note that as well as using C2/AS1 (Means of Escape) it is important also to consider certain aspects of C3/AS1 (Spread of Fire) which impact on the means of escape. The analysis therefore approaches the building as if it were a new building and then, subsequently, the applicable parts of the solution required under the law are drawn out.

3.1 Results from Analysis

As a result of the analysis in Appendix A it is clear that the stairways existing in the building are inadequate to comply fully with the requirements of clause C2 of the New Zealand building code.

The question is whether under Section 38 of the Building Act the stairways may be regarded as providing a solution which complies "as nearly as is reasonably practicable to the same extent as if it were a new building".

The answer to this must be negative since there is no way that unconscious patients under anaesthetic could be evacuated down these stairs. The question which then arises is "what are the reasonably practicable measures which could be taken to lead the building towards compliance with the code?".

In this case the answer is that more time must be gained so that fire service personnel can control the fire in one part of the building whilst rescue operations can be undertaken in the adjacent non-fire portion.

The simplest way of achieving this is to split each floor into two firecells each containing at least one stairway. In this way, no matter where the fire is, patients can be wheeled and other occupants walk through the fire separation into the non-fire portion of the building. If a one hour fire and smoke rating is provided there is clearly very much more time for life safety operations and the preservation of life of occupants and patients. Times taken to travel from one side of a particular floor to the other have been broadly assessed, as well as the time for descent down the stairs for various levels of disability, and the above solution clearly offers the best way to comply "as nearly as is reasonably practicable" with the requirements of the code itself, as stated.

4.0 Findings

In respect of life safety and fire rescue operations the building does not comply with the New Zealand building code as it presently stands (please note that this opinion is based on consideration of plans provided only - the building has not been visited).

If the building were to fully comply with the New Zealand building code, the actions in Section 4.1 below should be undertaken. Note however that:
(1) only those measures which may be deemed to comply "as nearly as is reasonably practicable to the same extent as if it were a new building" are in fact required.

(2) **The following therefore represents an optimum listing, which is it is unlikely to be practicable to achieve in full. The extent to which compliance might be expected is then discussed in Section 5.0 following.**

4.1 Optimum Life Safety Changes (see notes in 4.0 above)

- Upgrade heat detector system to smoke detectors in main working spaces, rooms and corridors. Heat detectors acceptable in cupboards etc as at present. Combined system to comply with F7/AS1.
- A voice communication system is required.
- The air-handling system should be fitted with smoke detectors so that the system will automatically shut down in the event of fire. There is no requirement to build in a specific smoke extract system, but there is an expectation that smoke will not enter non-fire spaces via the air handling system. At the very least the air conditioning plant must be equipped with smoke detectors on the supply side with prevention of smoke circulation whilst extract mode continues when required.
- Provide fire hose reels (location of these is not shown on plans provided).
- A fireman's lift control is desirable.
- Provide emergency lighting to F6/AS1 and signs to F8/AS1.
- Fire riser mains are recommended.
- A fire separation to a rating of -/60/60Sm should be provided to as nearly as possible bisect each clinical floor, and ensuring that each cell contains a stairway. This separation could make use of existing walls if they have such a rating. Fire doors to -/60/60Sm rating should be provided where necessary for access and if these are required to be held open during normal operation they should be held back on magnetic hold open devices which will release the doors on alarm (F7/AS1 1.4.5). Ensure that these fire separations extend up to the underside of the floor slab above and that there is no connection of concealed spaces above the ceiling level. Any air supply ducts traversing this fire separation should be fitted with fire dampers to automatically close on alarm.
- Ensure all doors to stairways are -/60/60Sm as above.
- Fire stop all penetrations through new work.
- Surface finishes (new work only):
  - a) Passageways, corridors and stairways not being part of an exitway:
    SFI not > 7
    SDI not > 5.
  - b) Sleeping areas and exitways:
    SFI = 0
    SDI not > 3.
  - c) Floor coverings:
    all floor coverings to be non-combustible.

5.0 Implementation

- Clearly the above actions represent major requirements in the context of the simple upgrade of a lower entry, and can hardly be deemed "reasonably practicable" in this setting.

- There is no way in which the stairs can easily be upgraded and therefore the option of gaining additional time by splitting the firecells in two is likely the simplest approach in the longer term.

- Note that the Approved Documents do not require sprinklers in a building of this height. However it may well be that the provision of sprinklers at the time of the next upgrade may be perhaps regarded as a more attractive alternative than the subdivision of each floor into two firecells each containing a stairway. Smoke-cell subdivision would still however be recommended in view of the slow evacuation time of disabled occupants.

- Discussions will need to be held between Health Waikato, the architects and the Territorial Authority to establish whether a programme of progressive upgrade for the rest of the building is required, and to what extent the listing in Section 4.1 above must be implemented.

6.0 Conclusion

In view of the relatively low level changes this present project proposes (involving merely a minor upgrade to the entry lobby) it may well be that the Territorial Authority is prepared to accept that at the present time it is not reasonably practicable to begin work in areas of the building not directly affected by this present project, but to accept assurances that at the time of future upgrades the above recommendations may be implemented on a step by step basis.

Yours sincerely,

J A Gibson
REGISTERED PROFESSIONAL ENGINEER

APPENDIX A

Fire Check Analysis for the Waiora Waikato Centre (Surgical Block).

1.0 Life Safety - Fire Cell Analysis Using C3/AS1 and the Fire Safety Annex

Purpose Groups & Fire Hazard Categories

Item	Basement	Lower ground floor	Ground floor	Floors 1, 2 & 3	Fourth floor plant room	Stairs and lift shafts	Total Building
Basic Information							
Number of levels in building*	4	4	4	4	4	4	4
Level	B	LG	G	1, 2 & 3	4	LG-4	As shown.
Fire Cell	A	B	C	D, E & F	G	S	As shown.
Approx. Area Considered (square metres).	3014	2959 + stairs/lift	2991 + stairs/lift	Level 1: 2991. Levels 2 & 3: 2780 + stairs/lift	2708 + stairs/lift	130 per floor	21,003
Purpose Groups and areas (approx sq m)							
Service areas/storage (IA)	3014	-	-	-	-	-	3014
Clinical (WL) (See note below)	-	2959	2991	1: 2991 2: 2780 3: 2780	-	-	14,501
Plant and services (IA)	-	-	-	-	2708	-	2708
Stairs & lift (IE))	-	130	130	130(x3)	130	As shown.	780
APPROX TOTAL (square metres)	3014	3089	3121	8941	2838	As shown.	21,003
Design Purpose Group	IA	WL/SC	WL/SC	WL/SC	IA	IE	As listed
Design Fire Hazard Category	1	2	2	2	1	1	As listed

* Based on n+1 stair flights, where n is the maximum number of full storey flights to reach a final exit.

Note: Although this is a hospital block no persons sleep overnight and many functions are office based. However, in view of the fact that operations under full anaesthetic occur here, firecells will be evaluated as both WL and SC. The reasoning behind this is that SC alone underestimates the number of people involved, whilst WL underestimates the hazard involved. Both must therefore be assumed where appropriate.

Occupancy

Results of investigation under clause A3.7 are included in the table below.

Item	Basement	Lower ground floor	Ground floor	Floors 1, 2 & 3	Fourth floor plant room	Stairs and lift shafts	Total Building
Occupancy							
Service areas/storage (IA)	-	-	-	-	-	-	-
Clinical (WL) (Based on actual office and waiting room use)	0	80	125	1: 125 2: 80 3: 80	Nil	-	490
Plant and services (IA)	-	-	-	-	-	-	-
Stairs & lift (IE))	-	-	-	-	-	-	-
Column Totals	0	80	125	285	Nil	-	490

Fire Safety Precautions (Tables B1, FSA)

Item	Basement	Lower ground floor	Ground floor	Floors 1, 2 & 3	Fourth floor plant room	Stairs and lift shafts
Life safety F-rating from tables B1 for building height 17 m.	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)
Required F value after adjustments from C3/AS1 2.5-2.13.	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)	F60 (WL) F60 (SC)
Minimum alarm type from tables B1 . Note effect of B2.5.3.	4 (WL) 4 (SC)	4 (WL) 4 (SC)	4 (WL) 4 (SC)	4 (WL) 4 (SC)	4 (WL) 4 (SC)	4 (WL) 4 (SC)
Actual alarm type presently installed	3	3	3	3	3	3
Description	Existing system is automatic fire alarm system with heat detectors and manual call points. Approved document requires upgrade to smoke detectors and manual call points.	As left	As left	As left	As left	As left

Item	Basement	Lower ground floor	Ground floor	Floors 1, 2 & 3	Fourth floor plant room	Stairs and lift shafts
Alarm type considering B2.5.3 and analysis elsewhere.	Existing type 3 detectors satisfy this clause	Existing type 3 detectors satisfy this clause	Existing type 3 detectors satisfy this clause	Existing type 3 detectors satisfy this clause	Existing type 3 detectors satisfy this clause	Existing type 3 detectors satisfy this clause
Final choice of alarm type.	5	5	5	5	5	5
Description	Combined heat and smoke detectors. Upgrade to smoke detectors in main working spaces, rooms and corridors. Heat detectors OK in cupboards etc.	As at left.	As at left.	As at left.	As at left.	As at left.
Other protection required	14, 15, 16, 18 (WL) 8, 9, 14, 15, 16, 18 (SC)	14, 15, 16, 18 (WL) 8, 9, 14, 15, 16, 18 (SC)	14, 15, 16, 18 (WL) 8, 9, 14, 15, 16, 18 (SC)	14, 15, 16, 18 (WL) 8, 9, 14, 15, 16, 18 (SC)	14, 15, 16, 18 (WL) 8, 9, 14, 15, 16, 18 (SC)	14, 15, 16, 18 (WL) 8, 9, 14, 15, 16, 18 (SC)
Key to other protection required: 8: Voice communication systems. 9: Smoke control in air-handling system. 14: Provide fire hose reels. 15: Fireman's lift control. 16: Provide emergency lighting in exitways 18: Fire hydrant systems.						

2.0 Other People's Property Protection.

- No wall study on radiation required.
- No study of S-ratings required under Section 38.
- In summary, fire resistance ratings require no changes under Section 38 of the Building Act:1991.

3.0 Means of Escape to C2/AS1

- **Basic Physical Characteristics**

Item	Basement	Lower ground floor	Ground floor	Floors 1, 2 & 3	Fourth floor plant room	Stairs and lift shafts
No. of escape routes from C2/AS1 Table 1 No. required (WL) No. provided (Note that if building were SC, 3 escape routes would allow up to 150 bed spaces). Any fire cells with single escape route per C2/AS1:5.3?	2 2 No	2 3 No	2 3 No	2 3 No	2 3 No	2 3 No
Result on number of escape routes	OK	OK	OK	OK	OK	OK
Width of escape routes from C2/AS1 Table 2 . Width required - minimum activity based width required. Horizontal (mm) Vertical (mm)	 850 1000	 1200 (SC) 850 (WL) 1500 (SC) 1000 (WL)	 1200 (SC) 850 (WL) 1500 (SC) 1000 (WL)	 1200 (SC) 850 (WL) 1500 (SC) 1000 (WL)	 850 1000	 1200 (SC) 850 (WL) 1500 (SC) 1000 (WL)
Minimum occupancy based width required:- Horizontal (8 mm per person) Vertical (9mm per person)	0 0	640mm 720mm	1000mm 1125mm	1000mm max 1125mm max	Nil Nil	0 0
Widths provided - Horizontal (mm): Vertical (mm):	Service tunnels OK. Escape stair tower N/A. Main stair N/A. Service stair 1300m (OK for WL).	All main corridors exceed 1800mm. Escape stair tower N/A. Main stair N/A. Service stair 1300m (OK for WL).	All main corridors exceed 1800mm. Escape stair tower 1000mm (OK for WL). Main stair 1500mm (OK for SC). Service stair 1300m (OK for WL).	All main corridors exceed 1800mm. Escape stair tower 1000mm (OK for WL). Main stair 1500mm (OK for SC). Service stair 1300m (OK for WL).	OK OK	As at left. As at left.
Result on width of escape route	OK for IA	OK for WL **Not OK for SC if main stair closed by fire.**	OK for WL **Not OK for SC if main stair closed by fire.**	OK for WL **Not OK for SC if main stair closed by fire.**	OK for IA	As at left.

Item	Basement	Lower ground floor	Ground floor	Floors 1, 2 & 3 (max)	Fourth floor plant room
Length of escape routes from C2/AS1 Table 3 (Calculated including stairs)					
Basic dead end open path length allowable (IA)	24m	-	-	-	24m
Basic dead end open path length allowable (SC)	-	8m	8m	8m	-
Basic dead end open path length allowable (WL)	-	18m	18m	18m	-
Basic total open path length allowable (IA)	60m	-	-	-	60m
Basic total open path length allowable (SC)	-	20m	20m	20m	-
Basic total open path length allowable (WL)	-	45m	45m	45m	-
Multiplier for sprinklers	-	-	-	-	-
Multiplier for heat detectors	1.15	1.15	1.15	1.15	1.15
Total maximum multiplier	1.15	1.15	1.15	1.15	1.15
Allowable dead end open path (IA)	27.6m	-	-	-	27.6m
Allowable dead end open path (SC)	-	9.2m	9.2m	9.2m	-
Allowable dead end open path (WL)	-	20.7m	20.7m	20.7m	-
Allowable total open path (IA)	69m	-	-	-	69m
Allowable total open path (SC)	-	23m	23m	23m	-
Allowable total open path (WL)	-	51.75m	51.75m	51.75m	-
Furthest horiz. distance to stairway acting as a potential safe path (C2/AS14.2.3)	N/A	42m (allowing 1 stair closed by fire)	42m (allowing 1 stair closed by fire)	42m (allowing 1 stair closed by fire)	59m
See note at base of table					
Results on lengths of escape routes assuming existing heat detectors only	OK	OK only when subdivided into open path lengths as set out in C2/AS1 2.5.7.	OK only when subdivided into open path lengths as set out in C2/AS1 2.5.7.	OK only when subdivided into open path lengths as set out in C2/AS1 2.5.7.	OK

Comment on Analysis:

At present only the exterior escape stair leads directly to a final exit. Thus the main stair opens into the public foyer at ground floor, thereby compromising its role as a safe path. Similarly the service stair opens into the northern lower ground floor lobby thus also compromising its role as a safe path.

The problems arising from this may be dealt with by considering both the service stair and the main public stair as open paths for their entire height. In this case the total open path length for purpose group WL from level four would be a maximum of 98m assuming that the escape stair is closed by fire. Actual travel time for this distance would be approximately 2.2 minutes from time of beginning to leave the building.

Note that warning may be some time in coming in view of the relatively slow detection time of heat detectors - probably around 3-4 minutes from ignition. Use of smoke detectors will enhance protection.

In essence the persons escaping are effectively in an open path of extended length. Paragraph C2/AS1 2.5.7 provides for a succession of up to four horizontal open paths on one escape route passing through fire separations. In this case, since each stairway (although re-classified as an open path where open lower lobbies exist) features fire doors at each floor and a further fire door at the lift lobby, no part of the total open path when subdivided then exceeds the allowable distance for WL uses. In fact the succession of open path situations on this basis gives a maximum distance of 41m. Existing partitioning is ignored in this exercise but will certainly have some fire resistance capability.

The above comments only apply if WL use is the only use. For SC, the building fails to comply unless additional fire separations are included on each clinical floor as stated above.

- **Check on Other Aspects of C2/AS1..**

Paragraph	Item	Action
1.0	Scope	As below.
2.1	Escape route general principles	As below
2.2	Number of escape routes	As above.
2.3	Size of escape routes	Height 2.1m min. OK Widths as above.
2.4	Length of escape routes	As above
2.5	Acceptable increases in open path lengths	As above .
2.6	Refuge areas	Consider separately.
2.7	Control of exitway activities	N/A
2.8	Escape through adjoining building	N/A
2.9	Escape routes from basements	N/A
3.0	Open paths	As above.
4.0	Exitways	Only the escape stair is classifiable as an exitway. Public stair and service stair become open paths as above due to their release into unprotected lobbies at lower levels.
5.0	Single escape routes	N/A
6.0	Special conditions for crowd and sleeping purpose groups	N/A if used as WL. See 6.3.1 for SC.
6.3.1	Safe path termination	Escape stair terminates in a safe place.
7.0	Features of escape routes	Ensure relevant details are specified
8.0	Smoke control	A special study should be undertaken on the ventilation and mechanical smoke control in this building. At the very least the air conditioning plant must be equipped with smoke detectors on the supply side with prevention of smoke circulation whilst extract mode continues when required.

4.0 Structural Stability

- No investigation required under Section 38 of the Building Act:1991.

5.0 Check of Means of Escape Implications of C3/AS1

Paragraph	Item	Action
1.0	General Principles	As below.
2.1	Fire construction details	New work only to comply.
2.2	Floors	N/A
2.3	Sub-floor spaces	N/A
2.4	Protected shafts	No upgrade required.
2.5-2.13	Specific Purpose Group requirements:-	As above.
2.14	Cross lease or unit titles	N/A
2.15	Foamed plastic building materials	Do not use unless discussed with the Fire Service.
2.16	Wood products	N/A
2.17	Fire service access	No upgrade required.
2.18	Fire fighting facilities Fire Hose Reels Fire Control Centre	No upgrade required.
3.0	Fire resistance ratings	No upgrade required
4.0	External walls and roof	No upgrade required
4.2	Building separation	OK as above.
4.3	FRR's of external walls	As above.
4.4	Vertical fire spread	N/A for WL use. For SC use vertical separation generally exceeds 2.5m with minor exceptions as noted.
4.5	Exposure at internal corners	N/A
4.6	Horizontal fire spread	N/A
4.8	Roofs	No upgrade required
4.9	Exterior surface finishes	No upgrade required
5.0	Closures	Ensure doors to all stairways are -/60/60Sm doors to effectively divide open path length into acceptable maxima as above. In addition provide appropriate doors to a standard "as nearly as is reasonably practicable to the same extent as if it were a new building" within floors. The rating of these doors to be not less than the existing partitions into which they are fitted - again the purpose is to limit the open path length. These fire doors should be fitted with magnetic hold open devices when installed. Detailed inspection and consideration of the fire rating performance of partitions within the floors is required before details are confirmed.
6.0	Fire stopping	No upgrade required, but where new work is installed fire stop all penetrations through existing floor and walls resulting from plumbing, electrical and other services. In particular the lobbies at the base of the public stair and the service stair should be made smoke proof when all doors leading from these lobbies are closed.
7.0	Concealed spaces	No upgrade required
8.0	Surface Finishes.	New work only. Passageways, corridors and stairways not being part of an exitway: SFI not > 7 SDI not > 5 Sleeping areas and exitways: SFI = 0 SDI not > 3 Floor coverings: All floor coverings to be non-combustible in SC use. No limit for WL use.
9.0	Smoke control.	As above. Undertake special check of supply and extract/exhaust system.

C1/1

CASE STUDY C1 = EGRESS

This example involves a 4 m high building 20 m wide by 20 m long.

The building is to be designed as a nightclub for 500 people.

This is based on 300 m^2 at 1.0 p.m^2 seated plus 100 m^2 at 2.0 p.m^2 standing.

There are three doors proposed as follows :-

D1	2400 mm	(Consider D1 as redundant.)
D2	1800 mm	
D3	1800 mm	

Refer page 83 and determine for 5 separate design cases :-

Case	1	2	3	4
td				
ta				
to				
ti				
tt				
tev	___	___	___	___
Tenability limits				
Safety factor				

Refer to page 86, Table 9.1

Refer to page 87, Figs 9.2 & 9.3.

Refer to FIRESYS PROGRAMME 9-B Fire Egress Widths (doors).

C1/2

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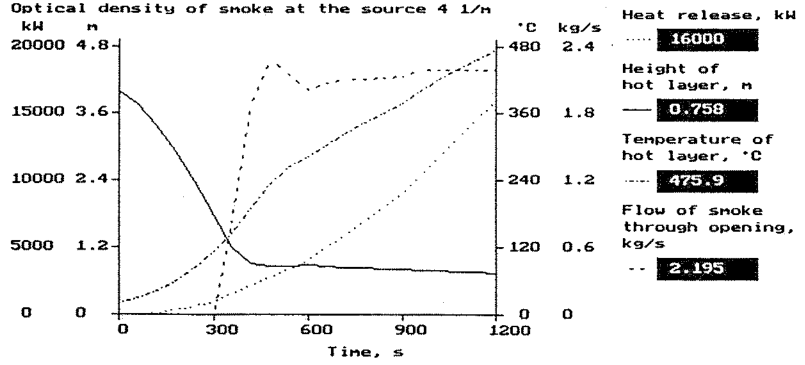
Program HotLayer
Hot layer model: room with one opening and ceiling ventilation.
Fire in the middle of the room (unimpeded entrainment).

Ceiling height 4 m
Room area 400 m²
Width of opening 2 m
Height of opening 2 m
Height of opening above the floor 0 m
Height of fire source above the floor 0.5 m
Number of independent fire sources 1
Optical density of smoke at the source 4 1/m

Flame temperature 1000 °C
Ambient temperature 20 °C
No ventilation.



Time s	Heat release kW	Height of hot layer m	Height of neutral plane m	Hot layer temperature oC	Flow of smoke through opening kg/s	Ceiling jet temperature oC	Ceiling jet optical density 1/m
0	0	4	4	20	0	20	0
60	40	3.78		30	0	40.8	0.17
120	160	3.4	3.59	42.4	0	70.5	0.41
180	360	2.92	3.15	61.1	0	109.9	0.69
240	640	2.38	2.63	85	0	157.7	1
300	1000	1.78	2.01 (1.5m)	112.7	0	210.2	1.32
360	1600	1.21	1.36	146.1	0.828	271.1	1.57
420	2200	0.93	1.02	190.3	1.876	331.4	1.58
480	2800	0.87	0.93	234.1	2.297	386.6	1.65
540	3400	0.87	0.98	265.2	2.153	426.6	1.74
600	4000	0.89	1.03	283.1	2.011	452.1	1.82
660	5000	0.87	1.01	303.4	2.072	482	1.91
720	6000	0.85	1	325.4	2.116	510.8	1.97
780	7000	0.84	1	344.6	2.115	535.1	2.01
840	8000	0.83	0.99	362.4	2.124	556.5	2.05
900	9000	0.81	0.99	379.2	2.134	575.8	2.07
960	10400	0.8	0.97	401.2	2.194	599.7	2.09
1020	11800	0.78	0.96	422	2.193	621.2	2.11
1080	13200	0.77	0.96	441.1	2.193	640.3	2.12
1140	14600	0.77	0.96	459	2.194	657.4	2.13
1200	16000	0.76	0.96	475.9	2.195	672.9	2.13

Tenability Limit = Smoke layer at 1.5m @ 120°C = 330 s = 5.5 mins.

c1/3

ASET-B version 1.0
SESOC Nightclub Mod Fire
09-12-1994
Heat loss fraction = .64
Fire height = 1.64042 ft .5 m
Room height = 13.12336 ft 4 m
Room area = 4305.564 sq ft 400 sq m

TIME sec	TEMP F	TEMP C	LAYER ft	LAYER m	FIRE kW	FIRE BTU/s
0.0	70.3	21.3	13.1	4.0	0.1	0.1
5.0	70.3	21.3	13.1	4.0	0.3	0.3
10.0	70.8	21.5	13.1	4.0	1.2	1.1
15.0	71.3	21.8	13.1	4.0	2.6	2.5
20.0	71.9	22.2	13.0	4.0	4.7	4.4
25.0	72.6	22.5	13.0	4.0	7.3	6.9
30.0	73.3	22.9	13.0	4.0	10.5	10.0
35.0	74.1	23.4	12.9	3.9	14.3	13.6
40.0	74.9	23.8	12.9	3.9	18.7	17.8
45.0	75.7	24.3	12.8 Average	3.9	23.7	22.5
50.0	76.6	24.8	12.8	3.9	29.3	27.7
55.0	77.6	25.3	12.7	3.9	35.4	33.6
60.0	78.5	25.9	12.7	3.9	42.1	40.0
65.0	79.5	26.4	12.6	3.8	49.4	46.9
70.0	80.6	27.0	12.5	3.8	57.3	54.4
75.0	81.7	27.6	12.5	3.8	65.8	62.4
80.0	82.8	28.2	12.4	3.8	74.9	71.0
85.0	83.9	28.9	12.3	3.8	84.5	80.2
90.0	85.1	29.5	12.3	3.7	94.8	89.9
95.0	86.4	30.2	12.2	3.7	105.6	100.2
100.0	87.6	30.9	12.1	3.7	117.0	111.0
105.0	88.9	31.6	12.0	3.7	129.0	122.4
110.0	90.3	32.4	11.9	3.6	141.6	134.3
115.0	91.7	33.2	11.8	3.6	154.7	146.8
120.0	93.1	34.0	11.8	3.6	168.5	159.8
125.0	94.6	34.8	11.7	3.6	182.8	173.4
130.0	96.1	35.6	11.6	3.5	197.7	187.5
135.0	97.6	36.5	11.5	3.5	213.2	202.3
140.0	99.2	37.4	11.4	3.5	229.3	217.5
145.0	100.9	38.3	11.3	3.4	246.0	233.3
150.0	102.6	39.2	11.2	3.4	263.3	249.7
155.0	104.3	40.2	11.1	3.4	281.1	266.6
160.0	106.1	41.2	11.0	3.4	299.5	284.1
165.0	107.9	42.2	10.9	3.3	318.5	302.1
170.0	109.8	43.2	10.8	3.3	338.1	320.7
175.0	111.7	44.3	10.7	3.3	358.3	339.9
180.0	113.7	45.4	10.6	3.2	379.1	359.6
185.0	115.8	46.5	10.5	3.2	400.4	379.8
190.0	117.9	47.7	10.4	3.2	422.4	400.6
195.0	120.0	48.9	10.3	3.1	444.9	422.0
200.0	122.2	50.1	10.2	3.1	468.0	443.9

Smoke Detector would operate at an average time = 45 seconds
= 0·8 minutes

c1/4

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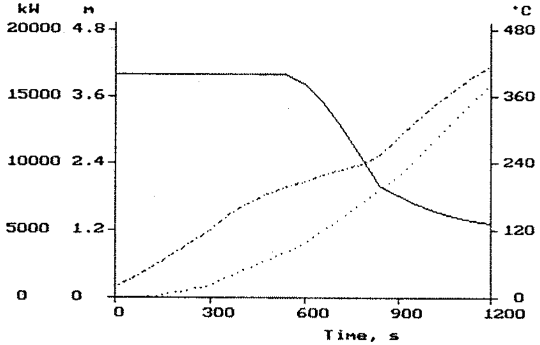
Program HotLayer

Hot layer model: room with one opening and ceiling ventilation.
Fire in the middle of the room (unimpeded entrainment).

Ceiling height 4 m
Room area 400 m²
Width of opening 2 m
Height of opening 2 m
Height of opening above the floor 0 m
Height of fire source above the floor 0.5 m
Number of independent fire sources 1
Optical density of smoke at the source 4 1/m

Flame temperature 1000 °C
Ambient temperature 20 °C
Exhaust ventilation 20 m3/s
Start-up delay 45 s



Time, s: **1200**
Heat release, kW: **16000**
Height of hot layer, m: **1.33**
Temperature of hot layer, °C: **416**
Flow of smoke through opening, kg/s: **0.000**

Time s	Heat release kW	Height of hot layer m	Height of neutral plane m	Hot layer temperature oC	Flow of smoke through opening kg/s	Ceiling jet temperature oC	Ceiling jet optical density 1/m
0	0	4	4	20	0	20	0
60	40	4		35	0	35.4	0.17
120	160	4	2	55	0	55.8	0.39
180	360	4	2	76.8	0	77.6	0.63
240	640	4	2	98.9	0	99.7	0.87
300	1000	4	2	120.5	0	121.4	1.11
360	1600	4	2	147.3	0	148.3	1.41
420	2200	4	2	167.9 (183°C)	0	168.6	1.63
480	2800	4	2	184.3	0	184.9	1.81
540	3400	4	2	197.8	0	198.4	1.96
600	4000	3.83	7.22	206.4	0	332.9	2.61
660	5000	3.51	6.48	219.3	0	369.1	2.89
720	6000	3.04	5.64	227.8	0	403.5	3.13
780	7000	2.53	4.9	238.1	0	436.8	3.35
840	8000	2	4.09	255.3	0	467.5	3.33
900	9000	1.82	3.66	288.2	0	502.3	3.14
960	10400	1.68	3.33	317.8	0	534.1	3
1020	11800	1.56	3.01	346	0	562.9	2.89
1080	13200	1.47	2.8	371.5	0	588.1	2.8
1140	14600	1.39	2.64	394.7	0	610.2	2.72
1200	16000	1.33	2.51	416	0	629.9	2.66

Tenability Limit = Temperature of 183°C at time = 470s = 7·9 mins

ESOC NIGHTCLUB MOD FIRE 09-12-1994

C|5

ire to eiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
3.5	2.5	20	57	250

inimum heat release rate necessary to activate the etector at the location described is 295 kW

ime(Sec)	RHR(kW)	Jet (C)	Head/det (C)
ime(Sec)	RHR(kW)	Jet (C)	Head/det. (C)
0	0	20	20
10	1	21	20
20	5	22	20
30	11	24	20
40	19	26	20
50	29	28	20
60	42	30	21
70	57	32	21
80	75	35	21
90	95	37	22
100	117	40	22
110	142	42	23
120	168	45	24
130	198	48	25
140	229	51	26
150	263	54	27
160	300	57	28
170	338	60	29
180	379	63	31
190	422	67	32
200	468	70	34
210	516	73	36
220	566	77	38
230	619	80	39
240	674	84	41
250	731	87	44
260	791	91	46
270	853	95	48
280	917	98	51
290	984	102	53
300	1053	106	56

---- Detector activation at 304.5 seconds ----

≈ 5.1 minutes

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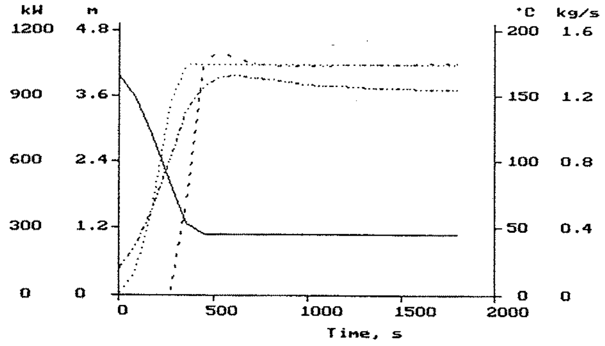
Program HotLayer
Hot layer model: room with one opening and ceiling ventilation.
Fire in the middle of the room (unimpeded entrainment).

C|6

Ceiling height 4 m
Room area 400 m²
Width of opening 2 m
Height of opening 2 m
Height of opening above the floor 0 m
Height of fire source above the floor 0.5 m
Number of independent fire sources 1
Optical density of smoke at the source 4 1/m

Flame temperature 1000 °C
Ambient temperature 20 °C
No ventilation.



Time, s
1800

Heat release, kW
1053

Height of hot layer, m
1.08

Temperature of hot layer, °C
155.5

Flow of smoke through opening, kg/s
1.405

Time s	Heat release kW	Height of hot layer m	Height of neutral plane m	Hot layer temperature oC	Flow of smoke through opening kg/s	Ceiling jet temperature oC	Ceiling jet optical density 1/m
0	0	4	4	20	0	20	0
90	105	3.59		36.3	0	57.5	0.31
180	379	2.89	3.24	63.3	0	113.7	0.72
270	864	2.03	2.45	101.8	0	190.1	1.21
360	1053	1.28	1.52	138.9	0.553	242.9	1.37
450	1053	1.1	1.19	158.3	1.421	262.4	1.27
540	1053	1.08	1.18	165.8	1.479	270.2	1.27
630	1053	1.09	1.19	166.7	1.433	271.2	1.27
720	1053	1.09	1.21	165.3	1.405	269.8	1.27
810	1053	1.09	1.21	163.4	1.394	267.9	1.27
900	1053	1.09	1.21	161.6	1.392	266.2	1.27
990	1053	1.09	1.21	160.2	1.393	264.7	1.27
1080	1053	1.09	1.2	159.1	1.396	263.6	1.27
1170	1053	1.09	1.2	158.2	1.398	262.7	1.27
1260	1053	1.08	1.2	157.5	1.4	262	1.26
1350	1053	1.08	1.2	156.9	1.401	261.5	1.26
1440	1053	1.08	1.2	156.5	1.403	261.1	1.26
1530	1053	1.08	1.2	156.2	1.404	260.7	1.26
1620	1053	1.08	1.2	155.9	1.404	260.4	1.26
1710	1053	1.08	1.2	155.7	1.405	260.2	1.26
1800	1053	1.08	1.2	155.5	1.405	260	1.26

(1.5m) (100°C)

Tenability Limit = Smoke layer at 1.5m @ 100°C = 320 s = 5.3 min

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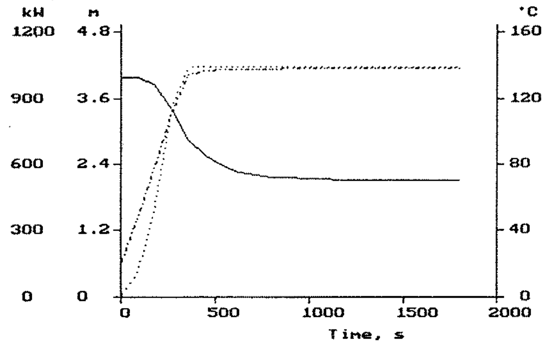
Program HotLayer
Hot layer model: room with one opening and ceiling ventilation.
Fire in the middle of the room (unimpeded entrainment).

9/7

Ceiling height 4 m	Flame temperature 1000 °C
Room area 400 m²	Ambient temperature 20 °C
Width of opening 2 m	Exhaust ventilation 4 m3/s
Height of opening 2 m	Start-up delay 45 s

Height of opening above the floor 0 m
Height of fire source above the floor 0.5 m
Number of independent fire sources 1
Optical density of smoke at the source 4 1/m



Time, s: 1800

Heat release, kW: 1053

Height of hot layer, m: 2.12

Temperature of hot layer, °C: 138.9

Flow of smoke through opening, kg/s: 0.000

Time s	Heat release kW	Height of hot layer m	Height of neutral plane m	Hot layer temperature oC	Flow of smoke through opening kg/s	Ceiling jet temperature oC	Ceiling jet optical density 1/m
0	0	4	4	20	0	20	0
90	105	4		46.9	0	47.8	0.3
180	379	3.87	3.66	76.8	0	111.6	0.71
270	864	3.41	3.98	111.9	0	178.1	1.2
360	1053	2.85	3.24	134.9	0	218.6	1.41
450	1053	2.55	2.86	137.7	0	227.2	1.42
540	1053	2.38	2.66	138.3	0	230.8	1.42
630	1053	2.28	2.55	138.6	0	232.7	1.42
720	1053	2.22	2.48	138.7	0	233.7	1.42
810	1053	2.18	2.44	138.8	0	234.4	1.42
900	1053	2.16	2.41	138.8	0	234.8	1.42
990	1053	2.14	2.39	138.9	0	235	1.42
1080	1053	2.13	2.38	138.9	0	235.2	1.42
1170	1053	2.13	2.38	138.9	0	235.2	1.42
1260	1053	2.12	2.37	138.9	0	235.3	1.42
1350	1053	2.12	2.37	138.9	0	235.4	1.42
1440	1053	2.12	2.37	138.9	0	235.3	1.42
1530	1053	2.12	2.37	138.9	0	235.4	1.42
1620	1053	2.12	2.37	138.9	0	235.4	1.42
1710	1053	2.12	2.37	138.9	0	235.4	1.42
1800	1053	2.12	2.37	138.9	0	235.4	1.42

Tenability Limit = Unlimited as smoke held above 2.0 m.

9/8

Date : 12-Sep-94

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PROGRAMME 9-A : FIRE EGRESS FROM ROOMS

Location : Nightclub

DEAD END PATH

Dead End Path Distance	Ld	=	0 m		
Number of Occupants	Nd	=	0 no		
Area of Dead End	Ad	=	0 m^2		
Design Density of Persons	Dd	=	0.00 p/m^2		
Speed of Travel	Sd	=	0.00 m/s	=	0 m/min
Time of Travel	td	=	0 s	=	0.00 min

DEAD END PLUS OPEN PATH

Dead + Open Path Distance	L	=	40 m		
Number of Occupants	N	=	250 no		
Area Containing Occupants	A	=	200 m^2		
Design Density of Persons	D	=	1.25 p/m^2		
Speed of Travel	S	=	0.93 m/s	=	56 m/min
Time of Travel	t	=	43 s	=	0.71 min

Date : 12-Sep-94

C1/9

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PROGRAMME 9-B : FIRE EGRESS WIDTHS (Doors and Corridors)

Location : Doors D2 & D3 D3

Nominal Width	Wn	=	1800 mm	
Unuseable Width	Wu	=	300 mm	
Effective Width	We	=	1500 mm	
Trial Flow Density	Dt	=	1.88 p/m^2	
Design Flow Density	D	=	1.88 p/m^2	
Speed Constant	k1	=	1.40 -	
Speed of Movement	S	=	0.70 m/s	= 42.0 m/min
Unit (or Specific) Flow	Fs	=	1.32 p/s/m	= 79.1 p/min/m
Total Calculated Flow	Fc	=	1.98 p/s	= 118.7 p/min
Persons per Effective Metre	Pm	=	167 p/m	
Effective Width Allowance	Ae	=	6.0 mm/p	18.91
Nominal Width Allowance	An	=	7.2 mm/p	
Flow Time (default = 150)	t	=	127 s	= 2.1 min
Length of Queu	Lq	=	89 m	
Persons in Queu	P	=	251 p	

C1/10

SUMMARY C1

Case

1 Manual alarm alone

2 Smoke detectors alone

3 Smoke removal system alone

4 Sprinklers alone

5 Smoke detectors, smoke removal amd sprinklers

Case	Minutes 1	2	3	4
td				
ta				
to				
ti				
tt				
tev	0	0	0	0
Tenability limit				
Safety factor				

CASE STUDY C2 = SEPARATION

This example involves a 4 m high building 30 m wide by 50 m long.

The front wall is 4 m back from the road boundary thereby creating a potential wing wall problem.

The left side wall is on the left boundary.

The right side wall is 5 m from the right side boundary.

The rear wall is 1 m from the rear boundary.

The openings in the walls are as follows :-

		Window No.	Width m	Height m
Front wall	W	1	3.000	1.500
	D	2	6.000	3.000
Right wall	D	3	3.000	3.000
	W	4	3.000	1.500
	W	5	3.000	1.500
	W	6	3.000	1.500
	W	7	3.000	1.500
	D	8	3.000	3.000
Rear wall	FW	9	6.000	1.500
	FW	10	1.000	1.500

There are no openings in the roof.

Determine total 80/30 rate of burning R80/30

Use the rate of burning to determine flame projection distances P from the non fire windows 1 to 8.

Determine separation distances S for the non fire windows and the fire windows.

Refer to page 79 Equation 8.4

Refer to page 80 Equation 8.6

—

Date : 12-Sep-94

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PROGRAMME 2-A : EFFECTIVE WALL OPENING

Floor Area : 1800 m^2

Opening No	Width w m	Height h m	Area Av m^2	wh^2 m^3
1	3.000	1.500	4.500	6.750
2	6.000	3.000	18.000	54.000
3	3.000	3.000	9.000	27.000
4	3.000	1.500	4.500	6.750
5	3.000	1.500	4.500	6.750
6	3.000	1.500	4.500	6.750
7	3.000	1.500	4.500	6.750
8	3.000	3.000	9.000	27.000
9	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000
Totals	27.000		58.500	141.750

Effective height	hv =	2.423 m
Effective width	wv =	24.143 m
Total Area	Av =	58.5 m^2
Openings as percentage of floor area	% =	3.3 %
Ventilation Factor	Fv =	91.062 m^2.5

—

MACBAR FRSYS02A

C2/3

Date	:	11-Sep-94	
FIRESYS	:	Fire Engineering Programme, Ver 1.1, 19 Apr 93.	
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Project Ref.	:	5000	
Project	:	SESOC Fire Engineering Seminar	
PROGRAMME 7	:	FIRE RESISTANCE RATINGS	

	(1)		
Fire Load Energy Density	ef =	800	MJ/m^2
Ambient Calorific Value	H'n =	15	MJ/kg
Firecell Width	W =	30.000	m
Firecell Depth	D =	50.000	m
Firecell Height	H =	4.000	m
Effective Opening Height	hv =	2.423	m
Effective Opening Width	wv =	24.143	m
External Coefficient	C1 =	2.0	-
Accessability Coefficient	C2 =	1.2	-
Floor Area	Af =	1500	m^2
Design Fire Area	Az =	625	m^2
Wall Area	Aw =	640	m^2
Opening Area	Av =	58	m^2
Openings to Floor Area Ratio	- =	0.04	-
Ventilation Factor	Fv =	91	m^2.5
Internal Surface Area 1	AT1 =	3640	m^2
Opening Factor 1	Fo1 =	0.025	m^1.5 (2)
Pyrolysis Coefficient	ke =	0.105	kg/s.m^2.5
Total Peak Rate of Burning	Re =	9.60	kg/s
Unit Peak Rate of Burning	rf =	0.015	kg/s.m
Fire Intensity	Qf =	143	MW
Fire Load Energy Density	ef =	800	MJ/m^2
Fire Load Energy Density	et =	137	MJ/m^2 (2)
Total Fire Load Energy	Ef =	1,200,000	MJ
Design Fire Load Energy	Ez =	500,000	MJ
Wood Equivalent Density	bf =	54	kg/m^2
Wood Equivalent Fire Load	Bf =	80,400	kg
Wood Equiv. Design Fire Load	Bz =	33,500	kg
Conversion Coefficient	c =	0.067	
Ventilation Coefficient	we =	1.086	
Fire Load Energy Density	ef =	800	
Equivalent Fire Duration	te =	58	min = 1.0 hr
		===	===

FIRE RESISTANCE RATING REQUIREMENTS

Fire Resistance Rating	FRR =	60	min
		===	

FIRE FIGHTING WATER REQUIREMENTS

Fire Zone	Z =	3	-
Minimum Water Flow	F =	86	l/s
Minimum Flow Duration	tw =	90	min = 1.5 hr
Minimum Water Storage	S =	463,865	litres
Standard 10 l/s Hoses	Hs =	9	No
		===	

Notes :

(1) Refer to "Macbar Fire Design Code" for further guidance.

(2) Can use "Fo1" and "et" to gauge fire severity in Swedish Fire Intensity Curves in Part 14 of Ref. (1).

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C2/4

Date	:	12-Sep-94
FIRESYS	:	Fire Engineering Programme, Ver 1.0, 30 Jul 93.
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Project Ref.	:	5000
Project	:	Fire Design Manual
PROGRAMME 4-A	:	FLAME SIZES FROM OPENINGS

Total 80/30 Rate of Burning (1)	R80/30	=	9.600 kg/s
Effective Width of Openings (2)	wv	=	24.143 m
Unit Opening Rate of Burning	rw	=	0.398 kg/s.m

	Opening		Wall Condition (3)		No-wall Condition (4	
	Width	Height	Flame Projection Distance	Flame Height Above Sill	Flame Projection Distance	Flame Height Above Sill
No.	w m	h m	P m	z1 m	P m	z1 m
1	3.000	1.500	0.322	6.921	1.697	10.058
2	6.000	3.000	0.644	6.921	1.392	10.058
3	3.000	3.000	0.930	6.921	1.392	10.058
4	3.000	1.500	0.322	6.921	0.877	10.058
5	3.000	1.500	0.322	6.921	0.877	10.058
6	3.000	1.500	0.322	6.921	0.877	10.058
7	3.000	1.500	0.322	6.921	0.877	10.058
8	3.000	3.000	0.930	6.921	1.392	10.058
9	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000

Notes

(1) Obtain R80/30 value from Programme 7 results.
(2) Obtain wv value from Programme 2-A results.
(3) "Wall Condition" relates to multi-storey walls or a single storey wall with a parapet above.
(4) No-wall Conditions" relates to a top-storey wall or a single storey wall with no parapet above.

-

Date : 12-Sep-94

C2/5

FIRESYS : Fire Engineering Programme, Ver 1.0, 30 Jul 93.
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Project Ref. : 5000
Project : SESOC Fire Engineering Seminar

PROGRAMME 8-A : SEPARATION DISTANCE FOR SINGLE OPENING

Opening Location : Window 1 Front of Projecting Flame

Glazing Type (Ord = 1, Fire Resist = 2)		G	=	1	-
Glazing Reduction Coefficient		k1	=	1.0	-
Height of Opening		H	=	1.500	m
Width of Opening		W	=	3.000	m
Area of Radiation Exposure		AE	=	5	m^2
Required Stability Time		FRR	=	60.00	mins
Ambient Temperature		T1	=	20	C
ISO Temperature Since Start		T2	=	945	C
Flame Emmissivity	(1)	e	=	1.0	-
Configuration Factor		CF	=	0.101	-
Facade Factor		FF	=	45	m^2
Emmitted Radiation Inside Firecell		IE1	=	124.5	kW/m^2
Emmitted Radiation Outside Firecell		IE2	=	124.5	kW/m^2
Received Radiation on Next Building		IR1	=	12.5	kW/m^2
Critical Incident Radiation Required		IRC	=	12.5	kW/m^2
Flame Projection Distance	(2)	P	=	1.697	m
Radiation Distance	(3)	R	=	3.520	m
Separation Distance from Adjoining Building		S	=	5.217	m

R Seek (4)

Starting Value for R	Rt	=	3.500	m
Incremental R Increase	Ri	=	0.010	m

Rt m	CF -	IR1 kW/m^2	IRC kW/m^2
3.500	0.102	12.7	12.5
3.510	0.101	12.6	12.5
3.520	0.101	12.5	12.5
3.530	0.100	12.5	12.5
3.540	0.100	12.4	12.5
3.550	0.099	12.4	12.5
3.560	0.099	12.3	12.5
3.570	0.098	12.2	12.5
3.580	0.098	12.2	12.5
3.590	0.097	12.1	12.5
3.600	0.097	12.1	12.5

MACBAR FRSYS08A

Date : 12-Sep-94

C2/6

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Project Ref. : 5000
Project : SESOC Fire Engineering Seminar

PROGRAMME 8-A : SEPARATION DISTANCE FOR SINGLE OPENING

Opening Location : Window 1 Side of Projecting Flame

Glazing Type (Ord = 1, Fire Resist = 2)		G	=	1	-
Glazing Reduction Coefficient		k1	=	1.0	-
Height of Opening		H	=	1.500	m
Width of Opening		W	=	1.697	m
Area of Radiation Exposure		AE	=	3	m^2
Required Stability Time		FRR	=	60.00	mins
Ambient Temperature		T1	=	20	C
ISO Temperature Since Start		T2	=	945	C
Flame Emmissivity	(1)	e	=	0.5	-
Configuration Factor		CF	=	0.200	-
Facade Factor		FF	=	13	m^2
Emmitted Radiation Inside Firecell		IE1	=	62.3	kW/m^2
Emmitted Radiation Outside Firecell		IE2	=	62.3	kW/m^2
Received Radiation on Next Building		IR1	=	12.5	kW/m^2
Critical Incident Radiation Required		IRC	=	12.5	kW/m^2
Flame Projection Distance	(2)	P	=	0.000	m
Radiation Distance	(3)	R	=	1.790	m
Separation Distance from Adjoining Building		S	=	1.790	m

R Seek (4)

Starting Value for R	Rt	=	1.700	m
Incremental R Increase	Ri	=	0.010	m

Rt m	CF -	IR1 kW/m^2	IRC kW/m^2
1.700	0.217	13.5	12.5
1.710	0.215	13.4	12.5
1.720	0.213	13.3	12.5
1.730	0.211	13.1	12.5
1.740	0.209	13.0	12.5
1.750	0.207	12.9	12.5
1.760	0.206	12.8	12.5
1.770	0.204	12.7	12.5
1.780	0.202	12.6	12.5
1.790	0.200	12.5	12.5
1.800	0.198	12.3	12.5

MACBAR FRSYS08A

Date : 12-Sep-94

C2/7

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Project : SESOC Fire Engineering Seminar

PROGRAMME 8-A : SEPARATION DISTANCE FOR SINGLE OPENING

Opening Location : Window 3 Front of Projecting Flame

Glazing Type (Ord = 1, Fire Resist = 2)		G	=	1 -
Glazing Reduction Coefficient		k1	=	1.0 -
Height of Opening		H	=	3.000 m
Width of Opening		W	=	3.000 m
Area of Radiation Exposure		AE	=	9 m^2
Required Stability Time		FRR	=	60.00 mins
Ambient Temperature		T1	=	20 C
ISO Temperature Since Start		T2	=	945 C
Flame Emmissivity	(1)	e	=	1.0 -
Configuration Factor		CF	=	0.101 -
Facade Factor		FF	=	89 m^2
Emmitted Radiation Inside Firecell		IE1	=	124.5 kW/m^2
Emmitted Radiation Outside Firecell		IE2	=	124.5 kW/m^2
Received Radiation on Next Building		IR1	=	12.5 kW/m^2
Critical Incident Radiation Required		IRC	=	12.5 kW/m^2
Flame Projection Distance	(2)	P	=	1.392 m
Radiation Distance	(3)	R	=	5.050 m
Separation Distance from Adjoining Building		S	=	6.442 m

R Seek (4) Starting Value for R Rt = 5.000 m
Incremental R Increase Ri = 0.010 m

Rt m	CF -	IR1 kW/m^2	IRC kW/m^2
5.000	0.102	12.7	12.5
5.010	0.102	12.7	12.5
5.020	0.102	12.7	12.5
5.030	0.101	12.6	12.5
5.040	0.101	12.6	12.5
5.050	0.101	12.5	12.5
5.060	0.100	12.5	12.5
5.070	0.100	12.4	12.5
5.080	0.100	12.4	12.5
5.090	0.099	12.3	12.5
5.100	0.099	12.3	12.5

-

12-Sep-94

C2/8

MACBAR FIRE ENGINEERING CALCULATION
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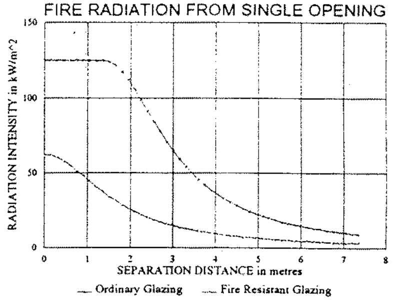
CALCULATED FIRE RADIATION FROM A SINGLE WINDOW

INPUT DATA

Project Title	:	Unit Factory Titles	
Window Description	:	Entry Door	
Height of Opening	H =	3.000 m	
Width of Opening	W =	3.000 m	
FRR Glazing Reduction Coeff.	k1 =	0.5 -	
Required Wall Stability Time	FRR =	60 mins	
Flame Projection Distance	P =	1.392 m	
Flame Emmissivity	e =	1.0 -	
Ambient Temperature	T1 =	20 C	
Incrementall Value of S	s =	0.150 m	

OUTPUT DATA

ISO Temperature Since Start	T2 =	945 C
Emitted Radiation inside Firecell	IE1 =	124.5 kW/m^2
Area of Radiation Exposure	AE =	9.0 m^2



S m	P m	R m	CF Ord	CF FRR	IE1 kW/m^2	IE2 kW/m^2	IE4 kW/m^2	IR1 kW/m^2	IR4 kW/m^2
0.000	1.392	0.000	1.000	1.000	124.5	124.5	62.3	124.5	62.3
0.150	1.392	0.000	1.000	0.992	124.5	124.5	62.3	124.5	61.8
0.300	1.392	0.000	1.000	0.968	124.5	124.5	62.3	124.5	60.3
0.450	1.392	0.000	1.000	0.932	124.5	124.5	62.3	124.5	58.0
0.600	1.392	0.000	1.000	0.885	124.5	124.5	62.3	124.5	55.1
0.750	1.392	0.000	1.000	0.831	124.5	124.5	62.3	124.5	51.7
0.900	1.392	0.000	1.000	0.774	124.5	124.5	62.3	124.5	48.2
1.050	1.392	0.000	1.000	0.716	124.5	124.5	62.3	124.5	44.6
1.200	1.392	0.000	1.000	0.659	124.5	124.5	62.3	124.5	41.0
1.350	1.392	0.000	1.000	0.605	124.5	124.5	62.3	124.5	37.7
1.500	1.392	0.108	0.996	0.554	124.5	124.5	62.3	124.0	34.5
1.650	1.392	0.258	0.976	0.507	124.5	124.5	62.3	121.6	31.6
1.800	1.392	0.408	0.943	0.464	124.5	124.5	62.3	117.4	28.9
1.950	1.392	0.558	0.899	0.425	124.5	124.5	62.3	111.9	26.5
2.100	1.392	0.708	0.847	0.390	124.5	124.5	62.3	105.4	24.3
2.250	1.392	0.858	0.790	0.358	124.5	124.5	62.3	98.4	22.3
2.400	1.392	1.008	0.732	0.329	124.5	124.5	62.3	91.2	20.5
2.550	1.392	1.158	0.675	0.303	124.5	124.5	62.3	84.0	18.9
2.700	1.392	1.308	0.620	0.280	124.5	124.5	62.3	77.2	17.4
2.850	1.392	1.458	0.568	0.258	124.5	124.5	62.3	70.7	16.1
3.000	1.392	1.608	0.520	0.239	124.5	124.5	62.3	64.7	14.9
3.150	1.392	1.758	0.476	0.222	124.5	124.5	62.3	59.2	13.8
3.300	1.392	1.908	0.436	0.207	124.5	124.5	62.3	54.2	12.9
3.450	1.392	2.058	0.399	0.193	124.5	124.5	62.3	49.7	12.0
3.600	1.392	2.208	0.366	0.180	124.5	124.5	62.3	45.6	11.2
3.750	1.392	2.358	0.337	0.168	124.5	124.5	62.3	41.9	10.5
3.900	1.392	2.508	0.310	0.158	124.5	124.5	62.3	38.6	9.8
4.050	1.392	2.658	0.286	0.148	124.5	124.5	62.3	35.6	9.2
4.200	1.392	2.808	0.264	0.139	124.5	124.5	62.3	32.9	8.7
4.350	1.392	2.958	0.245	0.131	124.5	124.5	62.3	30.5	8.1
4.500	1.392	3.108	0.227	0.123	124.5	124.5	62.3	28.3	7.7
4.650	1.392	3.258	0.211	0.116	124.5	124.5	62.3	26.3	7.2
4.800	1.392	3.408	0.196	0.110	124.5	124.5	62.3	24.5	6.9
4.950	1.392	3.558	0.183	0.104	124.5	124.5	62.3	22.8	6.5
5.100	1.392	3.708	0.171	0.099	124.5	124.5	62.3	21.3	6.2
5.250	1.392	3.858	0.160	0.094	124.5	124.5	62.3	20.0	5.8
5.400	1.392	4.008	0.150	0.089	124.5	124.5	62.3	18.7	5.5
5.550	1.392	4.158	0.141	0.085	124.5	124.5	62.3	17.6	5.3
5.700	1.392	4.308	0.133	0.081	124.5	124.5	62.3	16.6	5.0
5.850	1.392	4.458	0.125	0.077	124.5	124.5	62.3	15.6	4.8
6.000	1.392	4.608	0.118	0.073	124.5	124.5	62.3	14.7	4.6
6.150	1.392	4.758	0.112	0.070	124.5	124.5	62.3	13.9	4.4
6.300	1.392	4.908	0.106	0.067	124.5	124.5	62.3	13.2	4.2
6.450	1.392	5.058	0.100	0.064	124.5	124.5	62.3	12.5	4.0
6.600	1.392	5.208	0.095	0.062	124.5	124.5	62.3	11.8	3.8
6.750	1.392	5.358	0.090	0.059	124.5	124.5	62.3	11.3	3.7
6.900	1.392	5.508	0.086	0.057	124.5	124.5	62.3	10.7	3.5
7.050	1.392	5.658	0.082	0.054	124.5	124.5	62.3	10.2	3.4
7.200	1.392	5.808	0.078	0.052	124.5	124.5	62.3	9.7	3.3
7.350	1.392	5.958	0.074	0.050	124.5	124.5	62.3	9.3	3.1
7.500	1.392	6.108	0.071	0.048	124.5	124.5	62.3	8.9	3.0

Date : 11-Sep-94

C2/9

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Project Ref. : 5000
Project : SESOC Fire Engineering Seminar

PROGRAMME 8-A : SEPARATION DISTANCE FOR SINGLE OPENING

Opening Location : Window 9 Rear Wall Fire Window

Glazing Type (Ord = 1, Fire Resist = 2)		G	=	2	-
Glazing Reduction Coefficient		k1	=	0.5	-
Height of Opening		H	=	1.500	m
Width of Opening		W	=	6.000	m
Area of Radiation Exposure		AE	=	9.000	m^2
Required Stability Time		FRR	=	60	mins
Ambient Temperature		T1	=	20	C
ISO Temperature Since Start		T2	=	945	C
Flame Emmissivity	(1)	e	=	1.0	-
Configuration Factor		CF	=	0.803	-
Facade Factor		FF	=	11.2	m^2
Emmitted Radiation Inside Firecell		IE1	=	124.5	kW/m^2
Emmitted Radiation Outside Firecell		IE2	=	62.3	kW/m^2
Received Radiation on Next Building		IR1	=	50.0	kW/m^2
Critical Incident Radiation Required		IRC	=	50.0	kW/m^2
Flame Projection Distance	(2)	P	=	0.000	m
Radiation Distance	(3)	R	=	0.550	m
Separation Distance from Adjoining Building		S	=	0.550	m

R Seek (4)

Starting Value for R	Rt	=	0.500	m
Incremental R Increase	Ri	=	0.010	m

Rt m	CF -	IR1 kW/m^2	IRC kW/m^2
0.500	0.829	51.6	50.0
0.510	0.824	51.3	50.0
0.520	0.819	51.0	50.0
0.530	0.814	50.7	50.0
0.540	0.808	50.3	50.0
0.550	0.803	50.0	50.0
0.560	0.798	49.7	50.0
0.570	0.793	49.3	50.0
0.580	0.787	49.0	50.0
0.590	0.782	48.7	50.0
0.600	0.777	48.4	50.0

11-Sep-94

C2/10

MACBAR FIRE ENGINEERING CALCULATION

CALCULATED FIRE RADIATION FROM A SINGLE WINDOW

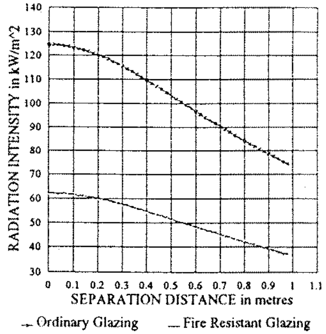
INPUT DATA

Project Title	:	SESOC Fire Engineering Seminar	
Window Description	:	Window 9	
Height of Opening	H =	1.500	m
Width of Opening	W =	6.000	m
FRR Glazing Reduction Coeff.	k1 =	0.5	-
Required Wall Stability Time	FRR =	60	mins
Flame Projection Distance	P =	0.000	m
Flame Emmissivity	e =	1.0	-
Ambient Temperature	T1 =	20	C
Incrementall Value of S	s =	0.020	m

OUTPUT DATA

ISO Temperature Since Start	T2 =	945	C
Emitted Radiation inside Firecell	IE1 =	124.5	kW/m^2
Area of Radiation Exposure	AE =	9.0	m^2

FIRE RADIATION FROM SINGLE OPENING



S m	P m	R m	CF Ord	CF FRR	IE1 kW/m^2	IE2 kW/m^2	IE4 kW/m^2	IR1 kW/m^2	IR4 kW/m^2
0.000	0.000	0.000	1.000	1.000	124.5	124.5	62.3	124.5	62.3
0.020	0.000	0.020	1.000	1.000	124.5	124.5	62.3	124.5	62.2
0.040	0.000	0.040	0.999	0.999	124.5	124.5	62.3	124.3	62.2
0.060	0.000	0.060	0.997	0.997	124.5	124.5	62.3	124.1	62.1
0.080	0.000	0.080	0.994	0.994	124.5	124.5	62.3	123.8	61.9
0.100	0.000	0.100	0.991	0.991	124.5	124.5	62.3	123.4	61.7
0.120	0.000	0.120	0.987	0.987	124.5	124.5	62.3	122.9	61.5
0.140	0.000	0.140	0.983	0.983	124.5	124.5	62.3	122.4	61.2
0.160	0.000	0.160	0.978	0.978	124.5	124.5	62.3	121.7	60.9
0.180	0.000	0.180	0.972	0.972	124.5	124.5	62.3	121.0	60.5
0.200	0.000	0.200	0.966	0.966	124.5	124.5	62.3	120.3	60.1
0.220	0.000	0.220	0.959	0.959	124.5	124.5	62.3	119.4	59.7
0.240	0.000	0.240	0.952	0.952	124.5	124.5	62.3	118.5	59.3
0.260	0.000	0.260	0.944	0.944	124.5	124.5	62.3	117.5	58.8
0.280	0.000	0.280	0.936	0.936	124.5	124.5	62.3	116.5	58.3
0.300	0.000	0.300	0.927	0.927	124.5	124.5	62.3	115.5	57.7
0.320	0.000	0.320	0.919	0.919	124.5	124.5	62.3	114.4	57.2
0.340	0.000	0.340	0.909	0.909	124.5	124.5	62.3	113.2	56.6
0.360	0.000	0.360	0.900	0.900	124.5	124.5	62.3	112.1	56.0
0.380	0.000	0.380	0.890	0.890	124.5	124.5	62.3	110.9	55.4
0.400	0.000	0.400	0.881	0.881	124.5	124.5	62.3	109.6	54.8
0.420	0.000	0.420	0.871	0.871	124.5	124.5	62.3	108.4	54.2
0.440	0.000	0.440	0.860	0.860	124.5	124.5	62.3	107.1	53.6
0.460	0.000	0.460	0.850	0.850	124.5	124.5	62.3	105.8	52.9
0.480	0.000	0.480	0.840	0.840	124.5	124.5	62.3	104.6	52.3
0.500	0.000	0.500	0.829	0.829	124.5	124.5	62.3	103.3	51.6
0.520	0.000	0.520	0.819	0.819	124.5	124.5	62.3	101.9	51.0
0.540	0.000	0.540	0.808	0.808	124.5	124.5	62.3	100.6	50.3
0.560	0.000	0.560	0.798	0.798	124.5	124.5	62.3	99.3	49.7
0.580	0.000	0.580	0.787	0.787	124.5	124.5	62.3	98.0	49.0
0.600	0.000	0.600	0.777	0.777	124.5	124.5	62.3	96.7	48.4
0.620	0.000	0.620	0.767	0.767	124.5	124.5	62.3	95.4	47.7
0.640	0.000	0.640	0.756	0.756	124.5	124.5	62.3	94.2	47.1
0.660	0.000	0.660	0.746	0.746	124.5	124.5	62.3	92.9	46.4
0.680	0.000	0.680	0.736	0.736	124.5	124.5	62.3	91.6	45.8
0.700	0.000	0.700	0.726	0.726	124.5	124.5	62.3	90.4	45.2
0.720	0.000	0.720	0.716	0.716	124.5	124.5	62.3	89.1	44.6
0.740	0.000	0.740	0.706	0.706	124.5	124.5	62.3	87.9	43.9
0.760	0.000	0.760	0.696	0.696	124.5	124.5	62.3	86.7	43.3
0.780	0.000	0.780	0.687	0.687	124.5	124.5	62.3	85.5	42.7
0.800	0.000	0.800	0.677	0.677	124.5	124.5	62.3	84.3	42.2
0.820	0.000	0.820	0.668	0.668	124.5	124.5	62.3	83.1	41.6
0.840	0.000	0.840	0.659	0.659	124.5	124.5	62.3	82.0	41.0
0.860	0.000	0.860	0.650	0.650	124.5	124.5	62.3	80.9	40.4
0.880	0.000	0.880	0.641	0.641	124.5	124.5	62.3	79.8	39.9
0.900	0.000	0.900	0.632	0.632	124.5	124.5	62.3	78.7	39.3
0.920	0.000	0.920	0.623	0.623	124.5	124.5	62.3	77.6	38.8
0.940	0.000	0.940	0.615	0.615	124.5	124.5	62.3	76.5	38.3
0.960	0.000	0.960	0.606	0.606	124.5	124.5	62.3	75.5	37.7
0.980	0.000	0.980	0.598	0.598	124.5	124.5	62.3	74.5	37.2
1.000	0.000	1.000	0.590	0.590	124.5	124.5	62.3	73.4	36.7

C3/1

CASE STUDY C3 = FLED versus HRR DESIGN

Refer to Table 6.2 Page 41

Refer to Equivalent Time Graphs attached.

Refer to worked example on page 42.

Refer to FIRESYS PROGRAMME 7 - Fire Resistance Rating example.

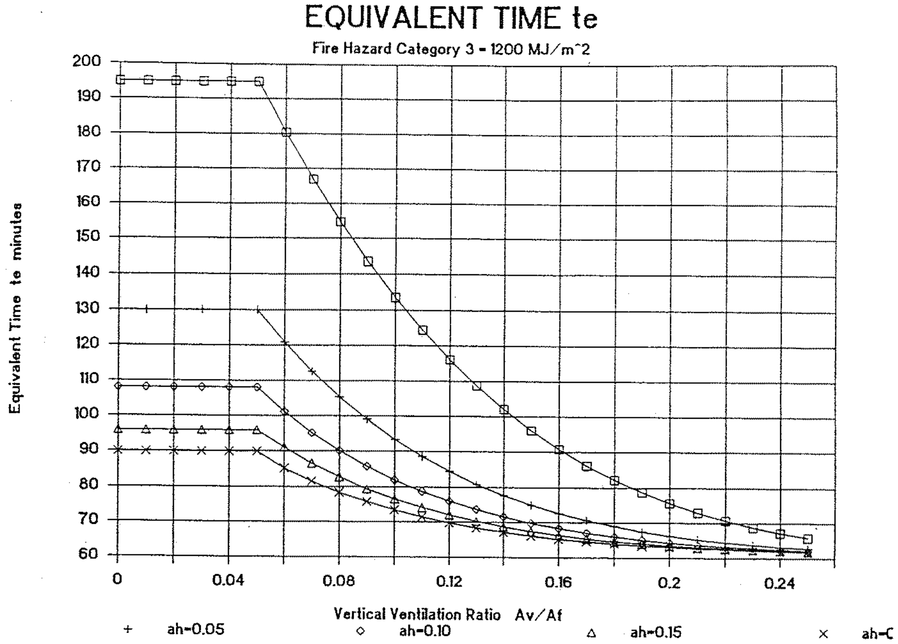
Refer to Page 28 Figure 4.4.

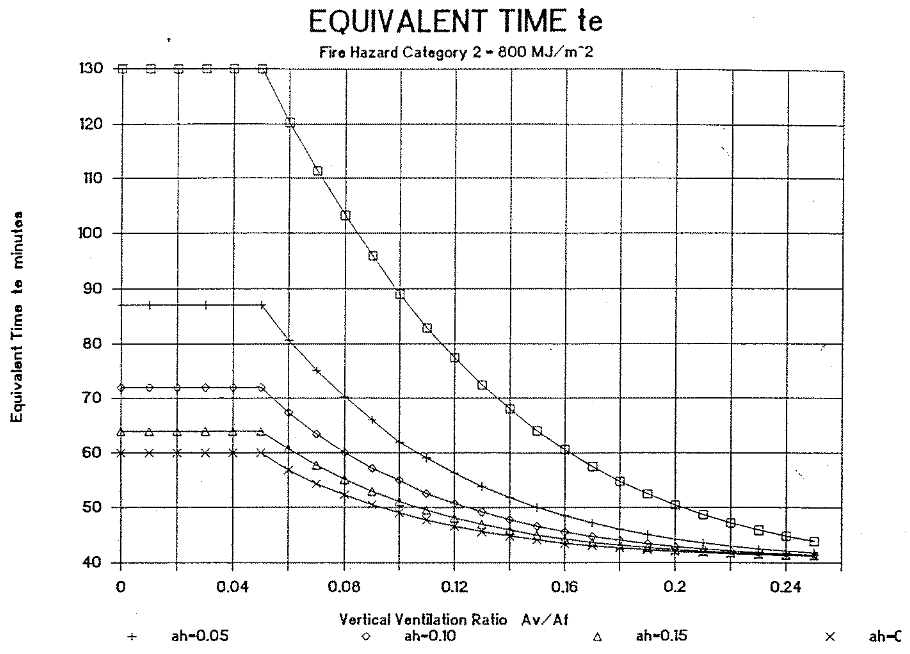
Refer to Page 35 Figures 5.2 and 5.3.

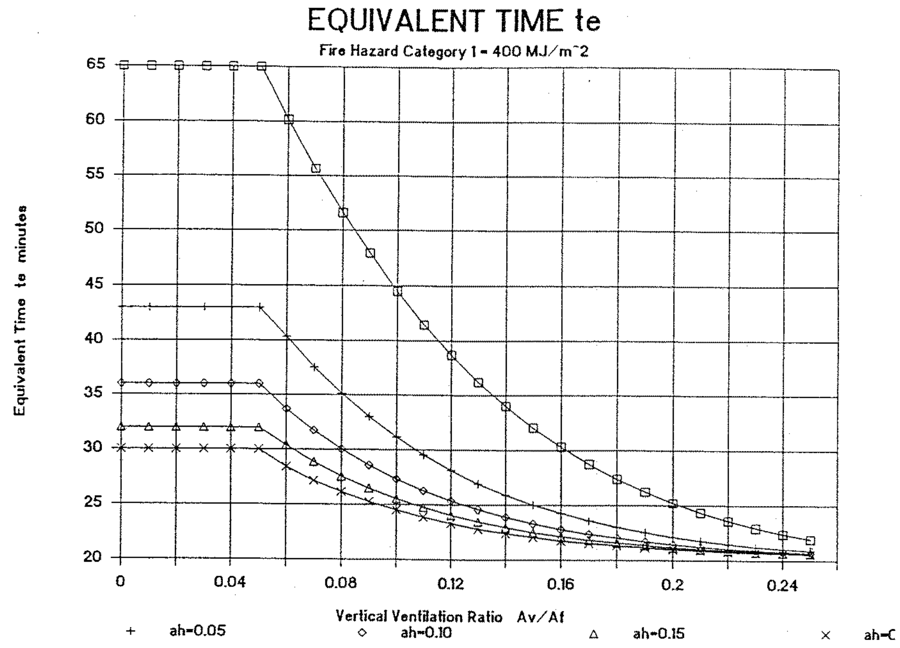
Refer to page 36 Figure 5.4.

Refer to FIRESYS PROGRAMME 3-G - Growth and Decay Curves.

C3/2




EQUIVALENT TIME te
Fire Hazard Category 2 = 800 MJ/m^2
Equivalent Time te minutes
130
120
110
100
90
80
70
60
50
40
0
0.04
0.08
0.12
0.16
0.2
0.24
Vertical Ventilation Ratio Av/Af
+ ah=0.05
◇ ah=0.10
△ ah=0.15
× ah=C


EQUIVALENT TIME te
Fire Hazard Category 1 = 400 MJ/m^2
Equivalent Time te minutes
65
60
55
50
45
40
35
30
25
20
0
0.04
0.08
0.12
0.16
0.2
0.24
Vertical Ventilation Ratio Av/Af
+ ah=0.05
◇ ah=0.10
△ ah=0.15
× ah=C

Date : 11-Sep-94

C3/5

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PROGRAMME 7 : FIRE RESISTANCE RATINGS

	(1)		
Fire Load Energy Density	ef =	800 MJ/m^2	
Ambient Calorific Value	H'n =	15 MJ/kg	
Firecell Width	W =	5.000 m	
Firecell Depth	D =	5.000 m	
Firecell Height	H =	3.000 m	
Effective Opening Height	hv =	2.000 m	
Effective Opening Width	wv =	3.000 m	
External Coefficient	C1 =	1.2 -	
Accessability Coefficient	C2 =	1.0 -	
Floor Area	Af =	25 m^2	
Design Fire Area	Az =	20 m^2	
Wall Area	Aw =	60 m^2	
Opening Area	Av =	6 m^2	
Openings to Floor Area Ratio	- =	0.24 -	
Ventilation Factor	Fv =	8 m^2.5	
Internal Surface Area 1	AT1 =	110 m^2	
Opening Factor 1	Fo1 =	0.077 m^1.5	(2)
Pyrolysis Coefficient	ke =	0.060 kg/s.m^2.5	
Total Peak Rate of Burning	Re =	0.51 kg/s	
Unit Peak Rate of Burning	rf =	0.025 kg/s.m	
Fire Intensity	Qf =	8 MW	
Fire Load Energy Density	ef =	800 MJ/m^2	
Fire Load Energy Density	et =	149 MJ/m^2	(2)
Total Fire Load Energy	Ef =	20,000 MJ	
Design Fire Load Energy	Ez =	16,393 MJ	
Wood Equivalent Density	bf =	54 kg/m^2	
Wood Equivalent Fire Load	Bf =	1,340 kg	
Wood Equiv. Design Fire Load	Bz =	1,098 kg	
Conversion Coefficient	c =	0.067	
Ventilation Coefficient	we =	0.671	
Fire Load Energy Density	ef =	800	
Equivalent Fire Duration	te =	36 min = 0.6 hr	
		=== ===	

FIRE RESISTANCE RATING REQUIREMENTS

Fire Resistance Rating	FRR =	60 min
		===

FIRE FIGHTING WATER REQUIREMENTS

Fire Zone	Z =	1 -
Minimum Water Flow	F =	5 l/s
Minimum Flow Duration	tw =	90 min = 1.5 hr
Minimum Water Storage	S =	24,616 litres
Standard 10 l/s Hoses	Hs =	0 No
		===

Notes :

(1) Refer to "Macbar Fire Design Code" for further guidance.

(2) Can use "Fo1" and "et" to gauge fire severity in Swedish Fire Intensity Curves in Part 14 of Ref. (1).

-

C3/6

of a ventilation-controlled fire and do not normally occur in the growth stage. The duration of the fully-developed stage depends on the total amount of fuel and the available ventilation.

The nature and arrangement of the fuel and the thermal properties of the walls and ceiling also affect the growth and intensity of a fully-developed fire.

Figure 4.4 shows typical time-temperature curves for fully-developed wood crib fires in firecells with varying fire load and ventilation. It can be seen that low ventilation produces longer, cooler fires than high ventilation. The more fuel available, the longer the fire burns. These curves are only indicative. Some tests have shown very similar results, whereas others have produced quite different time-temperature curves.

4.7 Decay stage

After a period of fully-developed burning, the fire intensity decreases as the fuel is consumed. Once the fuel supply diminishes to a point where it is unable to sustain the maximum burning rate, the fire is said to be in the decay stage. The transition to the decay stage is often defined as the time when 80% of the fuel has been consumed.

During the decay stage, the fire passes back from a ventilation-controlled fire to a fuel-controlled fire, with the burning rate governed by the fuel supply with more than sufficient air available for combustion of the remaining fuel. The fire continues to decay until the available fuel is consumed, and then goes out.

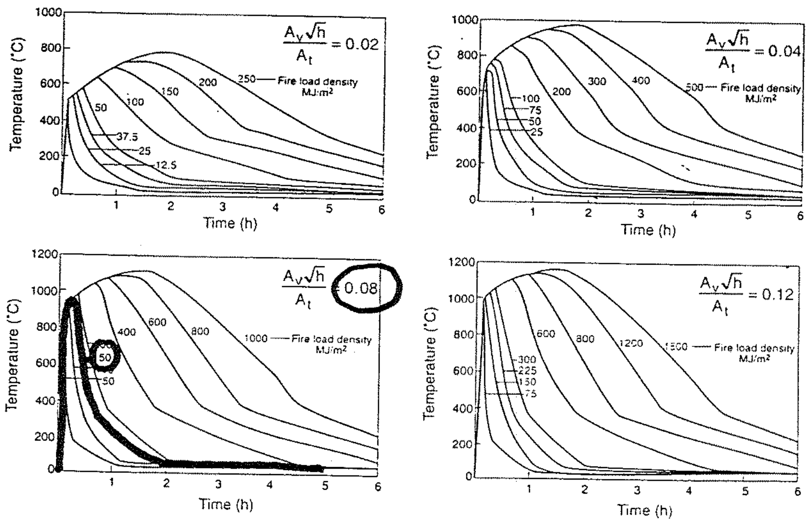

Figure 4.4: Time-temperature curves for various fuel loads and opening factors

Fuel load is MJ per square metre of bounding surfaces.

(Magnusson and Thelandersson 1970)

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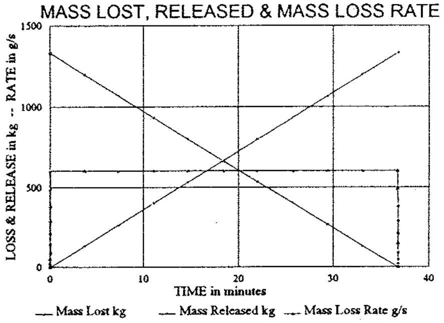
PROGRAMME 3-G : GROWTH & DECAY + VENTILATION OR FUEL SURFACE CONTROLLED MODEL

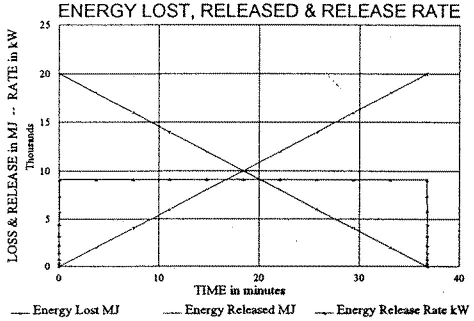
Fuel Type =CIB Test 205

Ambient Calorific Value	H'n	=	15 MJ/kg			Apha
Design Fire Load Energy	Ez	=	20000 MJ			a
Design Fire Load Mass	Bz	=	1333 kg			
Effective Opening Height	hv	=	2.000 m	UF	=	16
Effective Opening Width	wv	=	2.140 m	F	=	8
Growth Alpha Value	ag	=	1000.00 -	M	=	4
Decay Alpha Value	ad	=	1000.00 -	S	=	2
Ventilation Factor	Fv	=	6.05 m^2.5			
Ventilation Limit	Qv	=	9.08 MW			
Max Fire Intensity in Growth Phase	Qg	=	854.99 MW			

MASS LOST, RELEASED & MASS LOSS RATE



ENERGY LOST, RELEASED & RELEASE RATE



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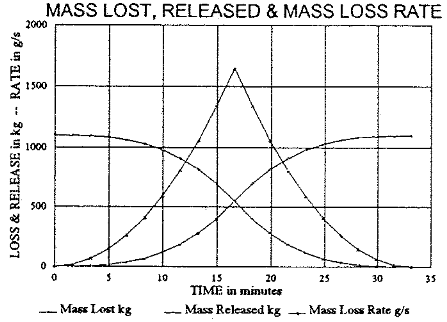
PROGRAMME 3-G : GROWTH & DECAY + VENTILATION OR FUEL SURFACE CONTROLLED MODEL

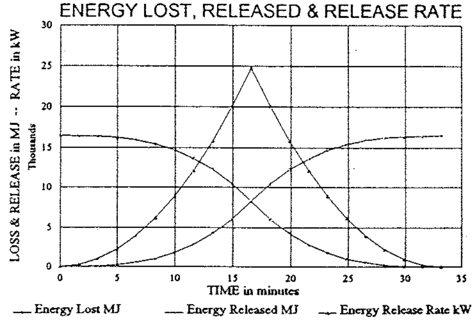
Fuel Type =CIB Test 205

Ambient Calorific Value	H'n	=	15 MJ/kg			Apha
Design Fire Load Energy	Ez	=	16393 MJ			a
Design Fire Load Mass	Bz	=	1093 kg			
Effective Opening Height	hv	=	3.200 m	UF	=	16
Effective Opening Width	wv	=	3.000 m	F	=	8
Growth Alpha Value	ag	=	6.00 -	M	=	4
Decay Alpha Value	ad	=	6.00 -	S	=	2
Ventilation Factor	Fv	=	17.17 m^2.5			
Ventilation Limit	Qv	=	25.76 MW			
Max Fire Intensity in Growth Phase	Qg	=	24.73 MW			

MASS LOST, RELEASED & MASS LOSS RATE



ENERGY LOST, RELEASED & RELEASE RATE



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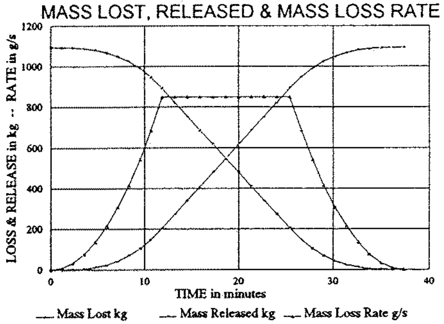
PROGRAMME 3-G : GROWTH & DECAY + VENTILATION OR FUEL SURFACE CONTROLLED MODEL

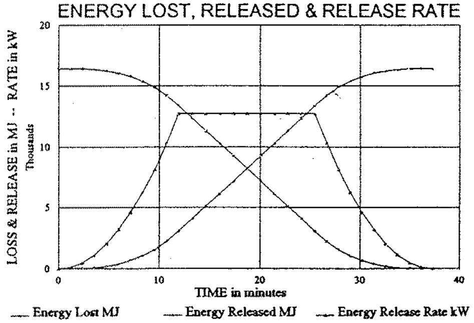
Fuel Type =CIB Test 205

Ambient Calorific Value	H'n	=	15 MJ/kg			Apha
Design Fire Load Energy	Ez	=	16393 MJ			a
Design Fire Load Mass	Bz	=	1093 kg			
Effective Opening Height	hv	=	2.000 m	UF	=	16
Effective Opening Width	wv	=	3.000 m	F	=	8
Growth Alpha Value	ag	=	6.00 -	M	=	4
Decay Alpha Value	ad	=	6.00 -	S	=	2
Ventilation Factor	Fv	=	8.49 m^2.5			
Ventilation Limit	Qv	=	12.73 MW			
Max Fire Intensity in Growth Phase	Qg	=	24.73 MW			

MASS LOST, RELEASED & MASS LOSS RATE



ENERGY LOST, RELEASED & RELEASE RATE



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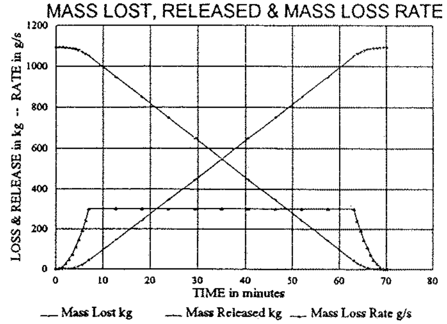
PROGRAMME 3-G : GROWTH & DECAY + VENTILATION OR FUEL SURFACE CONTROLLED MODEL

Fuel Type =CIB Test 205

Ambient Calorific Value	H'n	=	15 MJ/kg			Apha
Design Fire Load Energy	Ez	=	16393 MJ			a
Design Fire Load Mass	Bz	=	1093 kg			
Effective Opening Height	hv	=	1.000 m	UF	=	16
Effective Opening Width	wv	=	3.000 m	F	=	8
Growth Alpha Value	ag	=	6.00 -	M	=	4
Decay Alpha Value	ad	=	6.00 -	S	=	2
Ventilation Factor	Fv	=	3.00 m^2.5			
Ventilation Limit	Qv	=	4.50 MW			
Max Fire Intensity in Growth Phase	Qg	=	24.73 MW			

MASS LOST, RELEASED & MASS LOSS RATE



ENERGY LOST, RELEASED & RELEASE RATE

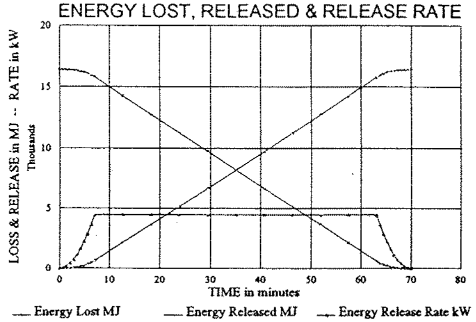


Table 1 of C3/AS1 with variations for height and kb.

"Table 1" Variations. **Gibson Consultants 1994.**

S Rating Based On: Time equivalent te= ef.kb.wf (min)

Notes on Input:

ef=	MJ/ m^2 as FHC
kb=	C3/AS1 uses 0.067
OR	Use 0.08 for insulating material Use 0.055 for plasterboard or concrete Use 0.045 for thin steel
w f	based on Ah/Af and Av/Af as table (see Eurocode formula)

Firecell Height (m)	3.600					
kb	0.055					
FLED (MJ/m^2)	800					
		Ah/Af				
Av/Af	bv	0	0.05	0.1	0.15	0.2
0.05	18.719	101	68	56	50	46
0.06	19.955	93	63	52	47	44
0.07	21.189	87	58	49	45	42
0.08	22.42	80	55	47	43	41
0.09	23.649	74	51	44	41	39
0.10	24.875	69	48	43	40	38
0.11	26.099	64	46	41	38	37
0.12	27.32	60	44	39	37	36
0.13	28.539	56	42	38	36	35
0.14	29.755	53	40	37	36	35
0.15	30.969	50	39	36	35	34
0.16	32.18	47	38	35	34	34
0.17	33.389	45	37	35	34	33
0.18	34.595	43	36	34	34	33
0.19	35.799	41	35	34	33	33
0.20	37	39	34	33	33	33
0.21	38.199	38	34	33	33	32
0.22	39.395	37	33	33	32	32
0.23	40.589	36	33	33	32	32
0.24	41.78	35	33	32	32	32
0.25	42.969	34	33	32	32	32

Table 1 of C3/AS1 with variations for height and kb.

	A	B	C	D	E	F	G	H	I
1		"Table 1" Variations.				Gibson Consultants 1994.			
2									
3		S Rating Based On:		Time equivalent		te=	ef.kb.wf	(min)	
4									
5		Notes on Input:		ef=	MJ/ m^2 as FHC				
6				kb=	C3/AS1 uses 0.067				
7				OR	Use 0.08 for insulating material				
8					Use 0.055 for plasterboard or concrete				
9					Use 0.045 for thin steel				
10				wf	based on Ah/Af and Av/Af as table				
11					(see Eurocode formula)				
12									
13		Firecell Height (m)				3.600			
14		kb				0.055			
15		FLED (MJ/m^2)				800			
16						Ah/Af			
17		Av/Af	bv	0	0.05	0.1	0.15	0.2	
18		0.05	18.719	101	68	56	50	46	
19		0.06	19.955	93	63	52	47	44	
20		0.07	21.189	87	58	49	45	42	
21		0.08	22.42	80	55	47	43	41	
22		0.09	23.649	74	51	44	41	39	
23		0.10	24.875	69	48	43	40	38	
24		0.11	26.099	64	46	41	38	37	
25		0.12	27.32	60	44	39	37	36	
26		0.13	28.539	56	42	38	36	35	
27		0.14	29.755	53	40	37	36	35	
28		0.15	30.969	50	39	36	35	34	
29		0.16	32.18	47	38	35	34	34	
30		0.17	33.389	45	37	35	34	33	
31		0.18	34.595	43	36	34	34	33	
32		0.19	35.799	41	35	34	33	33	
33		0.20	37	39	34	33	33	33	
34		0.21	38.199	38	34	33	33	32	
35		0.22	39.395	37	33	33	32	32	
36		0.23	40.589	36	33	33	32	32	
37		0.24	41.78	35	33	32	32	32	
38		0.25	42.969	34	33	32	32	32	
39									

```
=IF((12.5*(1+10*$B20-($B20*$B20)))<10,10,(12.5*(1+10*$B20-($B20*$B20))))
```

```
=$F$14*$F$15*(IF((((6/$F$13)^0.3)*((0.62+((90*(0.4-$B20)^4)/(1+$C20*D$17))))<0.5,0.5,(((6/$F$13)^0.3)*((0.62+((90*(0.4-$B20)^4)/(1+$C20*D$17)))))))
```