Experimental Results for Pre-Flashover Fire Experiments in Two Adjacent ISO Compartments.

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Abstract

This report presents the data obtained from the pre-flashover fire experiments conducted in a form such that the data could be used without further explanation from experiment operators. A total of 23 experiments were conducted from the 19th of December 2001 to the 29th of January 2002. They were conducted at the University of Canterbury McLeans Island testing facility. The experiments were conducted to help validate zone and field computer modelling programs, which are used to simulate fires in enclosures.

The experiments were conducted in a two adjoining room structure, separated by a doorway. Each compartment was 2.4m wide x 3.6m long x 2.4m high. The doorway was located in the centre of the wall and was 0.8m wide by 2.0m high. The three fire sizes used in the experiments were; 60kW, 120kW, and 180kW. In seven of the experiments a door was placed in the doorway separating the two compartments, and was set at various angles. Details of the experiments including the door are discussed further in Clark, 2002.

A number of arrangements on the front opening of the compartment were used. These were;

Unrestricted	- The opening of the compartment was unobstructed, with a size of 2.4m x 2.4m.
Soffit	- A soffit 0.39m deep was placed across the front opening.
Door Opening	- A doorway 2.01m high x 0.81m wide was created in the front opening.

Fire test data needs to be easily accessible for anyone with an interest in these tests. The world wide web provides an excellent medium for the exchange of this fire test data. The data collected from these experiments is stored in the XML format, which is a markup language built on the foundation of HTML. This format

was chosen over FDMS, the Fire Data Management System developed at the Building and Fire Research Laboratory (BFRL) at the National Institute for Standards and Technology (NIST), since it is very flexible, is easy to understand and is non-proprietary, and can easily be viewed and stored on the web. Since the format is flexible, there is a number of ways of storing the data, which can be very useful.

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1. Introduction

The aim of this project is to provide the data collected from the pre-flashover fire tests conducted at the McLeans Island site in such a format that the data could be utilised without requiring explanation from the experiment operators. The experiments were conducted from the 19th of December 2001 to the 29th of January 2002. A total of 23 experiments were conducted during this time. The experiments were performed to collect data to help validate computer models of a fire in an enclosure.

The two types of models that are used to simulate fires in enclosures are zone and field models. A zone model represents an enclosure as two separate gas layers; an upper and a lower layer. Equations for the conservation of energy, mass and species are applied to each zone and are used to predict layer temperatures and the layer height. Zone models are often used since they are easy to setup and run and are not computer intensive, although since the zone model is based on empirical correlations, the results can be inaccurate with irregular geometries. The computer program C-Fast is a commonly used zone model.

A field model is based on a time dependent, three dimensional solution of the mass, momentum and energy conservation equations. The enclosure is divided into small, three dimensional cells, and the conservation equations are applied to each of these small cells. This method is generally known as computational fluid dynamics (CFD), and does not rely on the assumptions and use of empirical correlations used in zone models. Field models require a good knowledge of fluid dynamics and require significantly more powerful computers than zone models, but do not have the limitations related to empirical equations.

The experiments were conducted in a two compartment structure, connected by a doorway. The experiments conducted in the two ISO room compartments were at fire sizes of 60kW, 120kW and 180kW provided by an LPG burner. The burner was located in the centre, corner and on the back wall on the centreline of the fire compartment in the experiments. Thermocouple trees were placed at the centreline of the compartments, with two other trees in one corner of each compartment. Thermocouples were also located in the doorway and in the front opening of the compartment. Surface temperatures on the ceiling and the floor were also measured. Aspirated thermocouples were placed in the doorway and on two of the thermocouple trees in the fire compartment. Bi-directional probes were placed in the doorway and front opening of the compartment and two further bi-directional probes were placed near the ceiling in the adjacent compartment to give gas speeds.

Three scenarios for the front opening configuration were tested: an unrestricted opening, the addition of a soffit to the opening, and the formation of a doorway in the front opening. A door, open at a number of angles, was also positioned in the central doorway for seven experiments. The range of configurations used in the experiments, and extent of the measurements, means that this set of data can be used for a wide range of applications.

Fire test data needs to be easily accessible and easy to understand. The format needs to be flexible enough to allow any type of fire test results to be stored. The world wide web provides an excellent location for data exchange. With the increase in use of the web in recent times, electronic data exchange has become commonplace. The problem with this data exchange is that there is no standard format for fire test data. Conversion of the test data is sometimes possible, but this can diminish the value of the data, and may make some data meaningless without knowledge of the actual experiments.

Two possible data formats were considered: FDMS and XML. The fire data management system (FDMS) was developed at the National Institute of Standards and Technology (NIST) in the U.S.A. XML or extensible markup language is being developed on the foundations provided by HTML, although it is much more flexible, and can also be used as a data interchange format between different applications. XML was chosen as the format that would be used to present the data obtained from the experiments because of its flexibility and the ease with which it can be placed on the web for availability to anyone who may have a use for it. The data will be available on the University of Canterbury Civil Engineering website, http://www.civil.canterbury.ac.nz, from December 2002.

2. Experimental

A two ISO compartment structure was used for the pre-flashover fire experiments from the 18th of December 2001 to the 29th of January 2002. The location of the experiments was at the University of Canterbury test facility at McLeans Island in Christchurch. This chapter describes the construction of the two-room compartment and provides details of the types and locations of the instrumentation used in the experiments.

2.1. Compartment Construction

The two-room compartment was constructed inside a building at the McLeans Island site to ensure stable ambient conditions during the experiments. Each room of the two-room compartment was an ISO standard full size room, which is 2.4m wide, 2.4m high and 3.6m in length. The compartments were joined by a doorway 0.8m wide and 2m high. Figure 2.1 shows the layout and dimensions of the two-room compartment. The room containing the burner will be designated as the fire compartment, the other room as the adjacent compartment.

A rigid steel box section frame with steel studs at 600mm centres was constructed. Wooden joists at a spacing of 600mm were attached to the rigid frame to provide the basis for the ceiling and floor. One layer of 12.5mm Gib® Fyreline was then attached to the walls, floor and ceiling. The frame of the structure was elevated 0.5m off the ground to allow for instrumentation under the compartment to be installed. Figure 2.2 is a photograph of the two-room compartment.

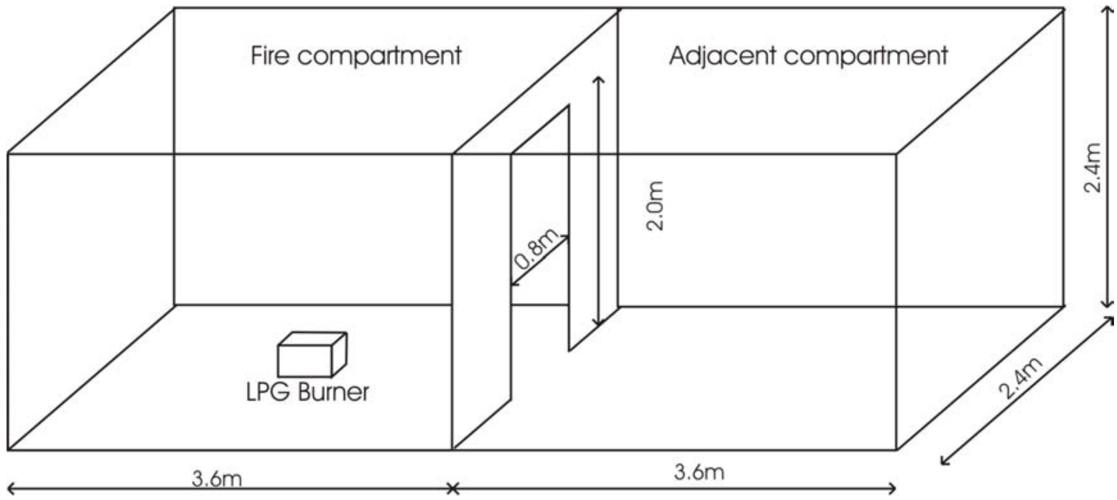

Figure 2.1. Compartment and doorway dimensions.

Figure 2.2. Two-room compartment at the McLeans Island test facility

2.2. Insulation Board

A layer of insulation board lined the compartment to protect the Gib® Fyreline during the experiments, since degradation of the Fyreline would occur by dehydration of the gypsum over time. The insulation board used was Triton Kaowool ceramic fibre, type 1260. The board was attached to the Gib® Fyreline using washers and screws. The insulation was placed on the walls, ceiling and floor, as well as lining the door frame and door. The door was used in seven of the experiments at a number of different angles. Section 2.9 of this report and Clark, 2002 contain further information on the door experiments. The properties of the insulation board are shown in table 2.1.

Sheet size (mm)	1000 x 500
Sheet thickness (mm)	10
Density (kgm^{-3})	250
Maximum service temperature (°C)	1260
Thermal conductivity at 200°C ($Wm^{-1}K^{-1}$)	0.07

Table 2.1. Triton Kaowool Ceramic fibreboard properties.

2.3. Burner

An LPG burner was used as a fire source in the experiments. The burner used in the experiments is a 300mm by 300mm burner filled with gravel, which was elevated 300mm off the floor. The LPG bottles providing the gas were located outside the building on a load cell. The load cell was a Toledo electronic scale with 12 bit accuracy, calibrated to 400 kg. The LPG flow rate was controlled using a high flow mass controller and meter. The mass controller is a Brooks model 5853 flow controller. The mass flow controller has an accuracy of ±1%. The flow rate was recorded throughout the experiments to obtain a heat release rate with time. The initial and final LPG mass was also recorded as a confirmation of the heat release rate.

The burner was ignited using a pilot flame, itself ignited using an electrical arc. The pilot flame extends over the burner to ensure rapid ignition of the LPG from the burner. The electrical arc was created using a high voltage transformer, which provided 15,000 volts, connected to two electrodes, 5mm to 10mm apart. The electrodes and pilot flame pipe can be seen in front of the burner in figure 2.3. The burner and spark igniter were switched off after ignition of the gas from the burner.

Figure 2.3. The burner in the corner location, with spark igniter and pilot flame in foreground.

2.4. Instrumentation

The instrumentation to be used in the experiments was set up after the Kaowool ceramic fibreboard was in place on the walls and ceiling. The floor was covered with the insulation board after instruments were in place to minimise damage to the board. The properties measured in the experiments were:

- temperature profiles
- gas speeds
- oxygen and carbon dioxide concentrations in the two-room compartment
- surface temperatures on the ceiling and floor of the two-room compartment.

2.5. Thermocouples

The thermocouple wire used was a type K, 24 gauge wire with glass insulation.

2.5.1. Thermocouple Trees

To obtain temperature profiles in the compartment, seven thermocouple trees were installed, with the thermocouples along the centreline of the two-room compartment. These thermocouple trees were constructed using a central 19mm stainless steel tube with small stainless steel tubes, extending 100mm from the central one. Each of these was located at a point where thermocouples were to be placed. The thermocouple wire passes through the small stainless steel tubes and down the large tube through the floor, where it was connected to the data recorder. Figure 2.4 is a photograph of a part of one of the thermocouple trees in the two-room compartment. The thermocouple trees were offset from the centreline to allow for the thermocouples to extend 100mm from the 19mm central stainless steel tube. The thermocouples were extended 100mm horizontally from the central tube to avoid conductive losses from the thermocouples. These thermocouple trees were at the following locations: 100mm from the back wall, 900mm from back wall, 1800mm from back wall, 2700mm from back wall, 900mm from the doorway wall, 1800mm from doorway wall, and 2700mm from doorway wall. Figure 2.6 shows the locations of the thermocouple trees. Each thermocouple tree consisted of 14 thermocouples at specific heights in the compartment. The distances of the thermocouples from the ceiling are given in table 2.3. The thermocouple trees positioned on the centreline of the compartment are named as shown in table 2.2 below.

Thermocouple Tree	Distance from wall (back or doorway)
1	100mm from back wall
2	900mm from back wall
3	1800mm from back wall
4	2700mm from back wall
5	900mm from doorway wall
6	1800mm from doorway wall
7	2700mm from doorway wall

Table 2.2. Centreline thermocouple tree naming with distance from the back or doorway wall.

Figure 2.4. Example of a thermocouple tree.

Two further thermocouple trees consisting of 16 thermocouples were placed 100mm from the side walls; one in the corner of the fire compartment, 100mm from the back wall; the other in the adjacent compartment in the corner, 100mm from the doorway wall. Figure 2.5 is a photograph of the side wall thermocouples. Figure 2.6 shows the thermocouple tree locations in relation to the burner locations.

Thermocouple Locations (mm from ceiling)	
Centreline TCs	50, 100, 200, 300, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000, 2200
Side wall TCs	100, 250, 400, 550, 700, 850, 1000, 1150, 1300, 1450, 1600, 1750, 1900, 2050, 2200, 2350

Table 2.3. Thermocouple locations for centreline and side wall trees as measured from the ceiling.

Figure 2.5. The sidewall thermocouples in the adjacent compartment.

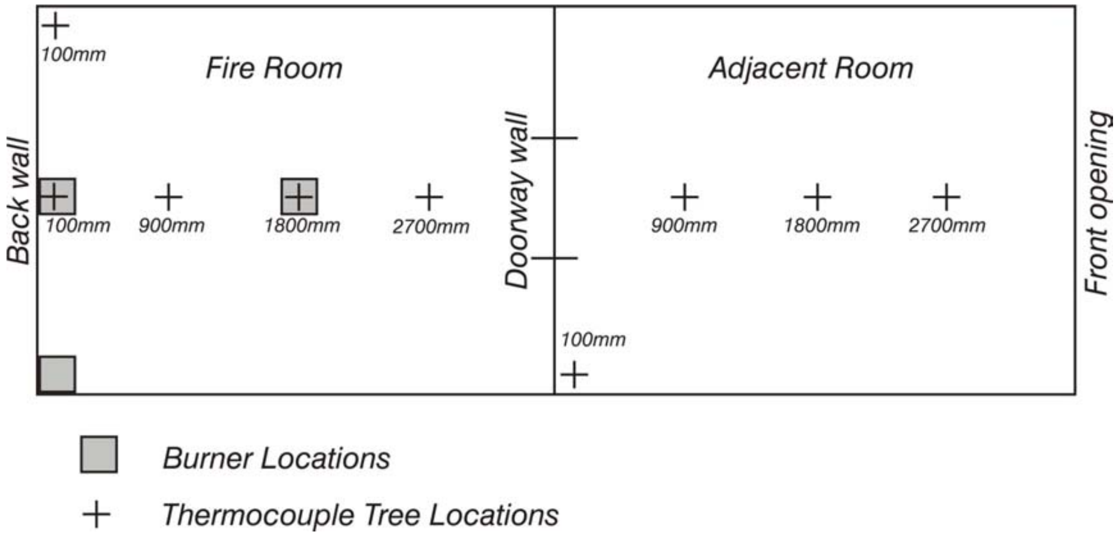

Figure 2.6. A plan view of the thermocouple tree locations in the compartment.

2.5.2. Door and Front Opening Thermocouples

Thermocouples were also located in the doorway and in the front opening of the compartment. These were placed 50mm from the measurement heads of the bi-directional probes. A thermocouple can be seen on the top bi-directional probe in figure 2.7 below. The bi-directional probes are moved during the experiment as described in section 2.8. The starting positions for the thermocouples in the doorway are given in table 2.4 below. Table 2.4 also shows the starting positions for the bi-directional probes before and after the addition of the soffit in the front opening, since the position of the topmost bi-directional probe is altered as explained in section 2.8.

Figure 2.7. A bi-directional probe with a thermocouple attached.

Thermocouple Locations (mm)	
Doorway (BC)	105, 350, 605, 850, 1100, 1365, 1610, 1860
Front Opening (BC)	250, 475, 735, 980,1235, 1490, 1761, 2000
(Before the addition of the soffit)	
Front Opening (BS)	75, 325, 585, 830, 1085, 1340, 1611, 1850
(After the addition of the soffit)	

Table 2.4. Thermocouple locations for the doorway and front opening. (BC=Below ceiling, BS=Below soffit).

2.5.3. Floor and Ceiling Thermocouples

The floor and ceiling temperatures were measured using thin steel plates, 100mm square, painted black to give the plates an absorptivity of approximately 1. A thermocouple wire was welded to the centre of the back of the plate. The plates were attached to the ceiling and floor using screws in two corners of the plates. The plates were attached to the compartment so that the centre of the plate was in line with each of the thermocouple trees and was at the centreline of the compartment. A total of 14 floor and ceiling temperatures were measured. Figure 2.8 shows the floor thermocouples located in the adjacent compartment.

Figure 2.8. The floor thermocouple plates in the adjacent compartment.

2.5.4. Aspirated Thermocouples

Aspirated thermocouples are used to correct for radiation effects from the fire. Radiation can affect the temperature reading given by unprotected thermocouples since these will absorb radiation from the fire and increase the temperature of the thermocouple. The aspirated thermocouples are insulated by a 6mm stainless steel tube. The stainless steel tubes are connected to copper tubing, which is connected to a manifold. The manifold is connected to a pump, which draws air from the compartment at the centreline of the two-room compartment through the stainless steel tubes. This ensures that radiation from the fire does not affect the temperature given by the thermocouple.

Aspirated thermocouples were located in the fire compartment as well as in the doorway. Six thermocouples were located in the doorway and a further six were located in the fire compartment. Three aspirated thermocouples were positioned on both thermocouple tree number two and tree number four. The aspirated thermocouples are not used in the adjacent compartment since there will be less radiation to these thermocouples as they are further from the source of the fire. The aspirated thermocouples were used in the doorway to provide accurate temperatures to calculate densities of the air flowing through the doorway. This leads to more accurate gas flow results.

The locations of the aspirated thermocouples in the fire compartment and doorway are given in table 2.5. Figure 2.9 shows the locations of the aspirated thermocouples in the doorway, and figure 2.10 shows the locations of the six other aspirated thermocouples on a side elevation of the two-room compartment. The aspirated thermocouples in the doorway were located 150mm from the edge of the doorway. The six aspirated thermocouples situated on thermocouple trees 2 and 4 were at the centreline of the compartment.

Location	Distance from ceiling (mm below ceiling)	Location	Distance from soffit (mm below soffit)
Tree #2	200	Doorway	100
Tree #2	1400	Doorway	350
Tree #2	2000	Doorway	600
Tree #4	200	Doorway	1350
Tree #4	1400	Doorway	1600
Tree #4	2000	Doorway	1850

Table 2.5. Aspirated thermocouple locations.

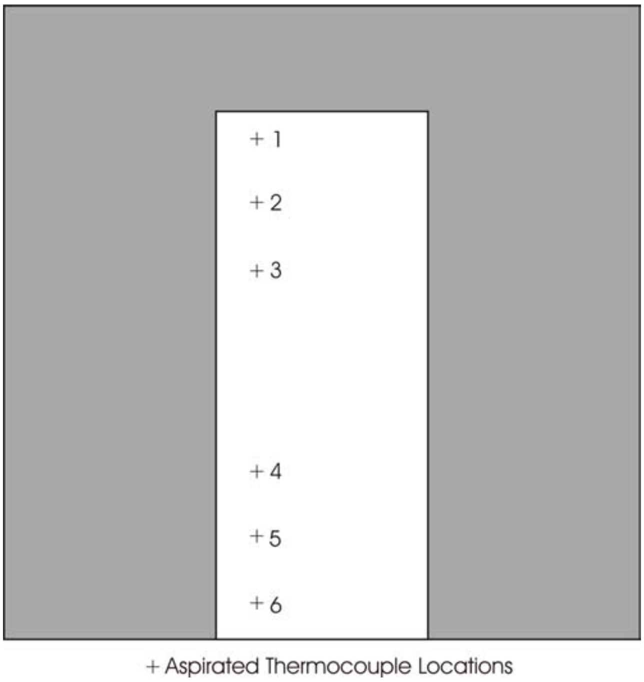

Figure 2.9. Aspirated thermocouples in the doorway looking into the fire compartment from the adjacent compartment.

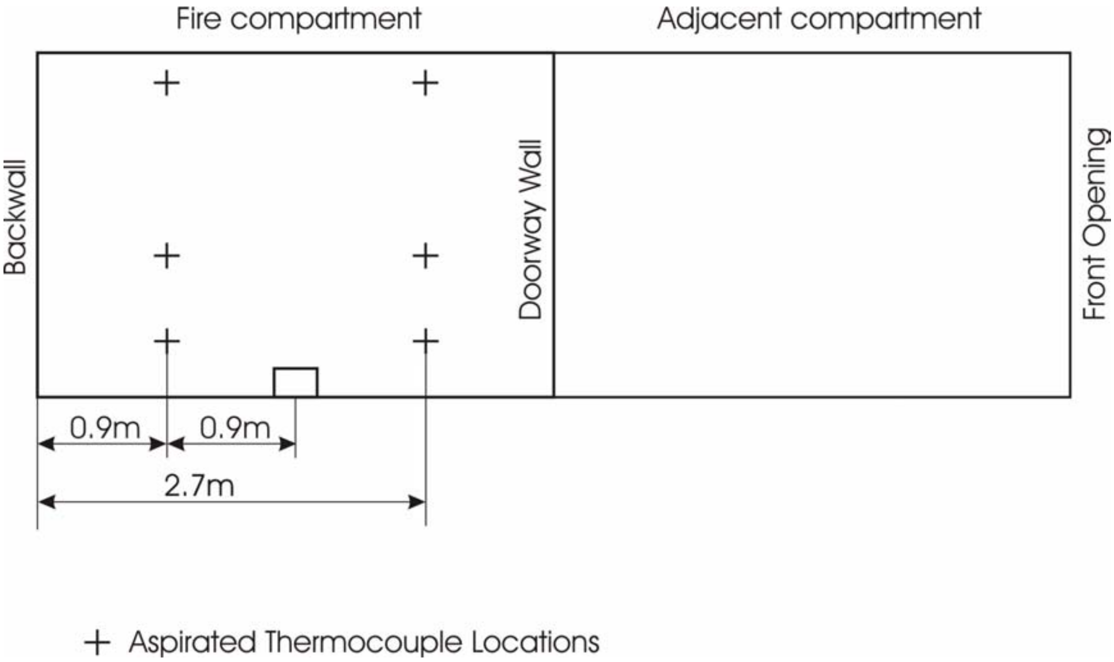

Figure 2.10. A side elevation of the aspirated thermocouples located along the centreline of the two-room compartment.

2.5.5. Ambient Thermocouples

The ambient temperature was measured at two locations outside of the two-room compartment during the experiments. The first was at the top of the apparatus approximately 3100mm from the back wall of the compartment, and the second at approximately 200mm above the floor level of the compartment, also approximately 3100mm from the back wall.

2.6. Bi-directional Probes

Bi-directional probes were used to measure gas speeds through the doorway and front opening, as well as near the ceiling in the adjacent compartment. 18 bi-directional probes were used, eight in the doorway, eight in the front opening, and two in the adjacent compartment. The bi-directional probes in the adjacent compartment were located at 100mm below the ceiling, on tree 5 and tree 7. These two bi-directional probes were located at this height to give an indication of the gas speed of the ceiling jet in the adjacent compartment. The bi-directional probes in the doorway are initially located 100mm from the edge of the doorway, as shown in figure 2.11. The distances of these below the doorway soffit are given in table 2.6. These measurements have a range of distances since they are moved during the experiments, as explained in section 2.8.

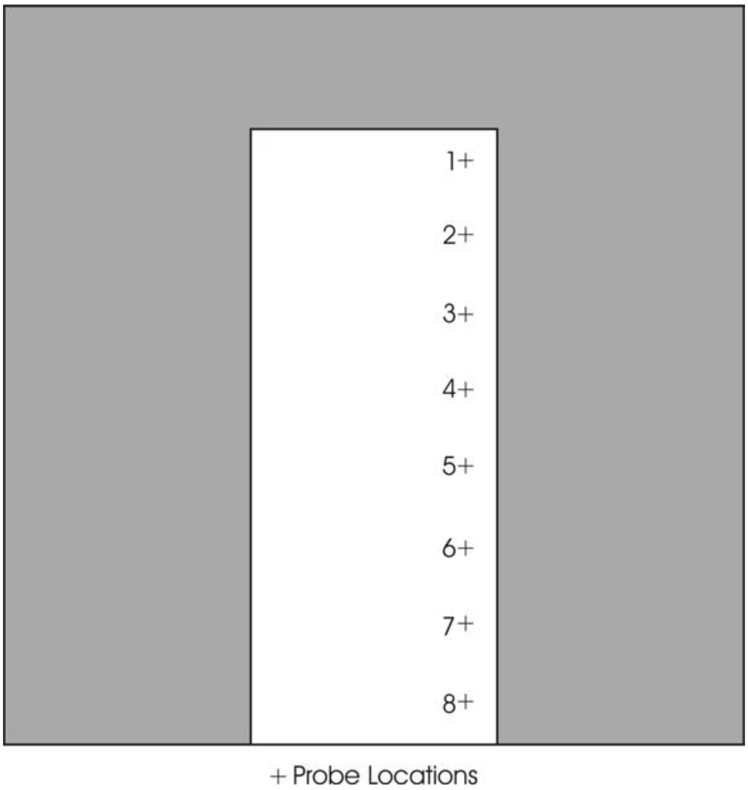

Figure 2.11. Bi-directional probe starting locations, looking into the fire compartment from the adjacent compartment.

Probe Number	Distance from soffit (mm)
1	105-120
2	350-360
3	605-615
4	850-855
5	1100-1110
6	1365-1385
7	1610-1615
8	1860-1870

Table 2.6. Doorway bi-directional probe locations measured from the doorway soffit.

Figure 2.12. Bi-directional probes in the front opening of the compartment.

The locations of the bi-directional probes positioned in the front opening for the experiments with an unrestricted front opening (experiments 00 to 13), are shown in table 2.7. For further details about the various front opening configurations see section 2.9. For the unrestricted front opening experiments the bi-directional probes were located at the centreline of the compartment.

For experiments 14 to 16, a soffit was added to the front opening. This meant that the top bi-directional probe was moved to the bottom of the opening, to a distance of 1850mm below the soffit. At this point the probes were renumbered such that the top bi-directional probe was always probe number 9. The distances are again shown in table 2.7. The bi-directional probes remained at the centreline of the compartment.

For experiments 17 to 22, a doorway is formed in the front opening of the two-room compartment. The bi-directional probes are moved during these six experiments, so a range of distances from the soffit are given in table 2.7.

Probe Number	Experiment numbers 00-13 (mm BC)	Experiment numbers 14-16 (mm BS)	Experiment numbers 17-22 (mm BS)
1	250	75	75-80
2	475	325	325-330
3	735	585	580-590
4	980	830	830-830
5	1235	1085	1080-1090
6	1490	1340	1340-1350
7	1761	1611	1600-1620
8	2000	1850	1840-1855

Table 2.7. Front opening bi-directional probe locations. (BC=Below ceiling, BS, Below soffit).

2.7. Oxygen and Carbon Dioxide Measurement

To measure the oxygen and carbon dioxide concentrations in the compartment, 20 gas measurement lines were positioned in the compartment. Eight of these were located in the doorway, and the remaining 12 were spread throughout the two-room compartment. The table below, table 2.8, gives the locations of the gas measurement probes of the first twelve probes, which are spread throughout the two-room compartment.

Probe Number	Thermocouple Tree	Distance below Ceiling (mm)
1	2	150
2	4	150
3	6	150
4	2	450
5	4	450
6	6	450
7	2	1750
8	4	1750
9	6	1750
10	2	2000
11	4	2000
12	6	2000

Table 2.8. Location of gas concentration measurement probes in the compartment.

The gas measurement probes 1 to 12 measured the gas concentrations at the centreline of the compartment. Figure 2.13 is a side elevation of the two-room compartment and shows the locations of the gas measurement probes, numbers 1-12.

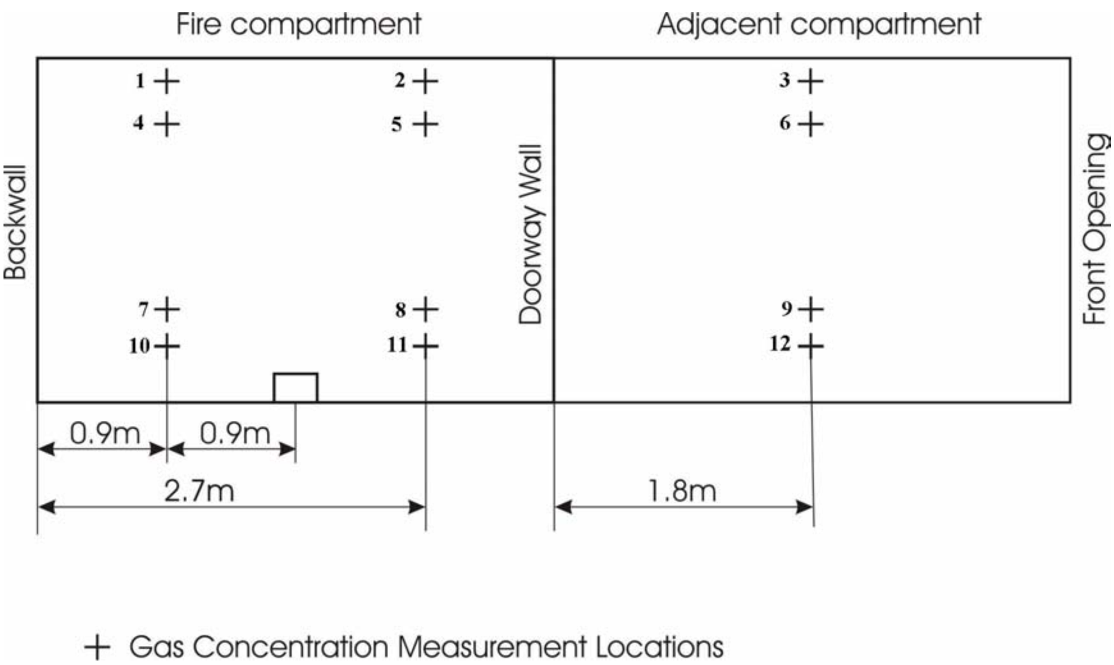

Figure 2.13. A side elevation of the gas concentration measurement probe locations for probes 1-12.

Sample probes 13 to 20 were installed 100mm from the edge of the doorway. Figure 2.14 shows the gas measurement locations 13-20. Table 2.9 gives details of the distances of the probes below the soffit.

Probe Number	Distance below doorway soffit (mm)
13	100
14	350
15	600
16	850
17	1100
18	1350
19	1600
20	1850

Table 2.9. Location of gas concentration measurement probes in the doorway.

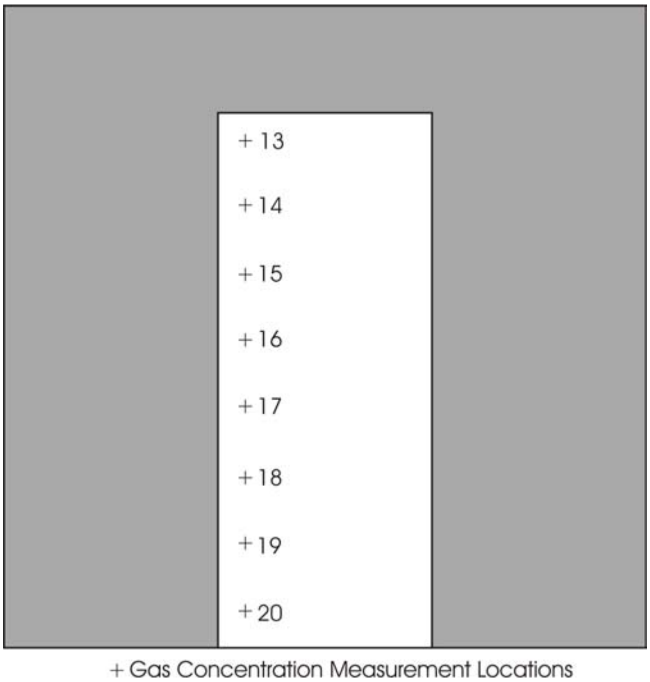

Figure 2.14. Gas concentration measurement locations in the doorway.

For experimental runs 19-22, a further four gas sample probes were installed in the compartment. These were in the front opening of the compartment at the points shown in table 2.10. They were installed 100mm from the edge of the front doorway. The locations of these are shown in figure 2.15.

Probe Number	Distance below doorway soffit (mm)
21	70
22	330
23	590
24	830

Table 2.10. Location of gas concentration measurement probes in the front opening used for experiments 19-22.

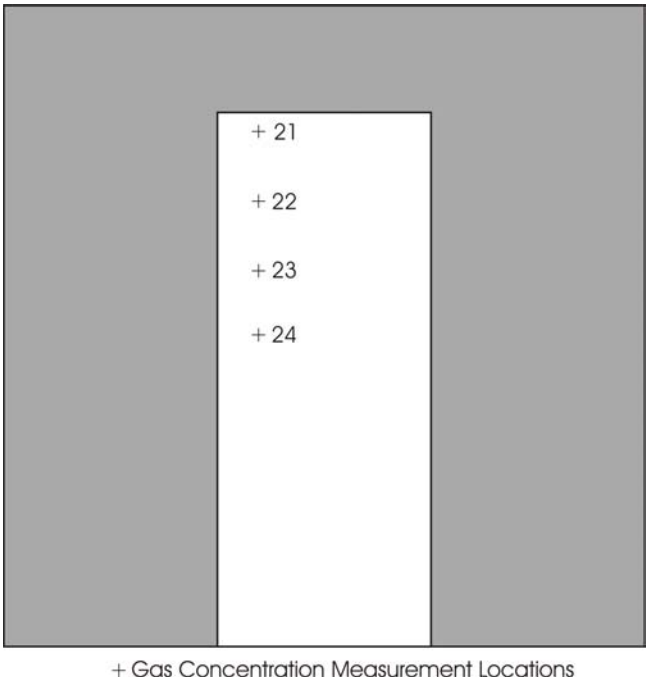

Figure 2.15. Gas concentration measurement locations for the doorway in the front opening, looking into the two-room compartment.

A Servomax 540A paramagnetic oxygen analyser was used for O_2 concentrations and a Siemens Ultramat 6.0 NDIR gas analyser was used for CO_2 concentrations. A manifold, shown in figure 2.16, with manual quarter-turn valves was used so that a gas analysis at each measurement location could be completed. The location being measured is changed every three minutes as explained in section 2.8.

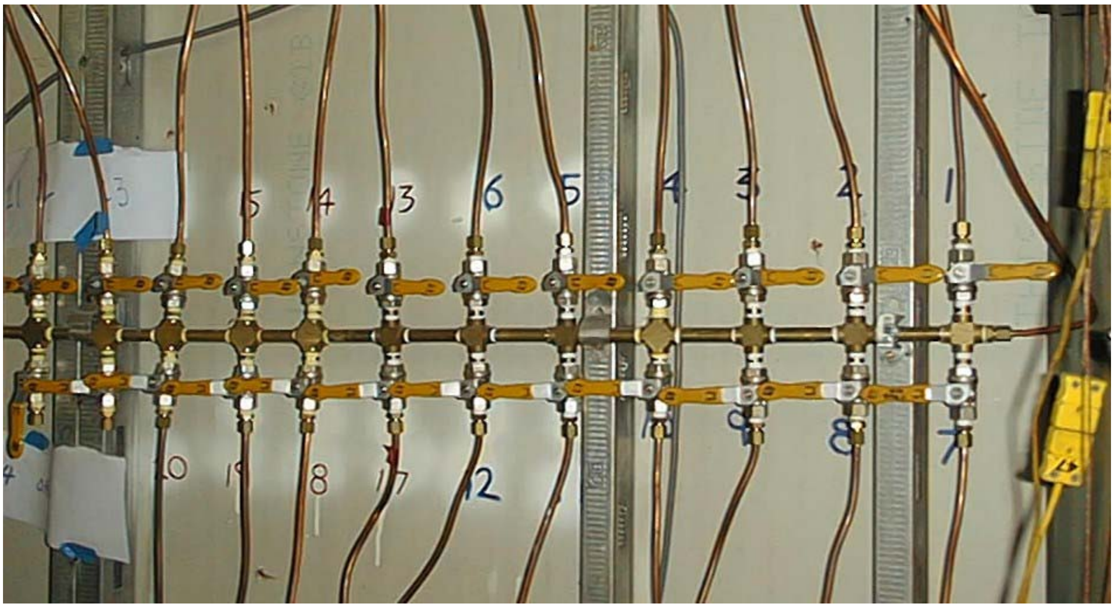

Figure 2.16. The manifold and valves on the gas sample lines.

2.8. *Procedure*

A three minute base line in ambient conditions was recorded for each of the experimental runs. The pilot flame and then burner were ignited, followed by a period of 10 minutes to allow a steady state to be reached in the two-room compartment. During the last five minutes of this period, gas concentration measurement is carried out from the topmost probe in the doorway, probe 13. After this period, at time 13 minutes, the gas measurement position is changed to probe location 01 from the topmost doorway probe. Tables 2.8, 2.9 and 2.10 in section 2.7 show the positions of each gas measurement probe. The gas measurement location is then changed every three minutes, moving from 01 to 20 (or to 24 in experiments 19 to 22). After measuring the gas concentrations from each location, the gas measurement position is then changed back to the topmost probe in the doorway for another three minutes to check for experimental reproducibility. The gas supply to the burner is then shut off, and another 3 minutes of data is logged. At this point the data logger is also stopped.

The bi-directional probes in the doorway and front opening are moved during the experiments, and therefore the position of the thermocouples attached to the bi-directional probes changes. In experiments 01 to 22, the bi-directional probes are 100mm from the edge of the doorway for the 13 minute 'start-up' period, and then are moved to each measurement location for 10 minutes at a time. The measurement locations are 100mm, 200mm, 300mm, 400mm, and 500mm, all measured from the edge of the doorway. Figure 2.17 shows the locations of the bi-directional probes in the doorway. After remaining at each of these positions for 10 minutes, the probe is moved back to its original position, 100mm from the edge of the doorway.

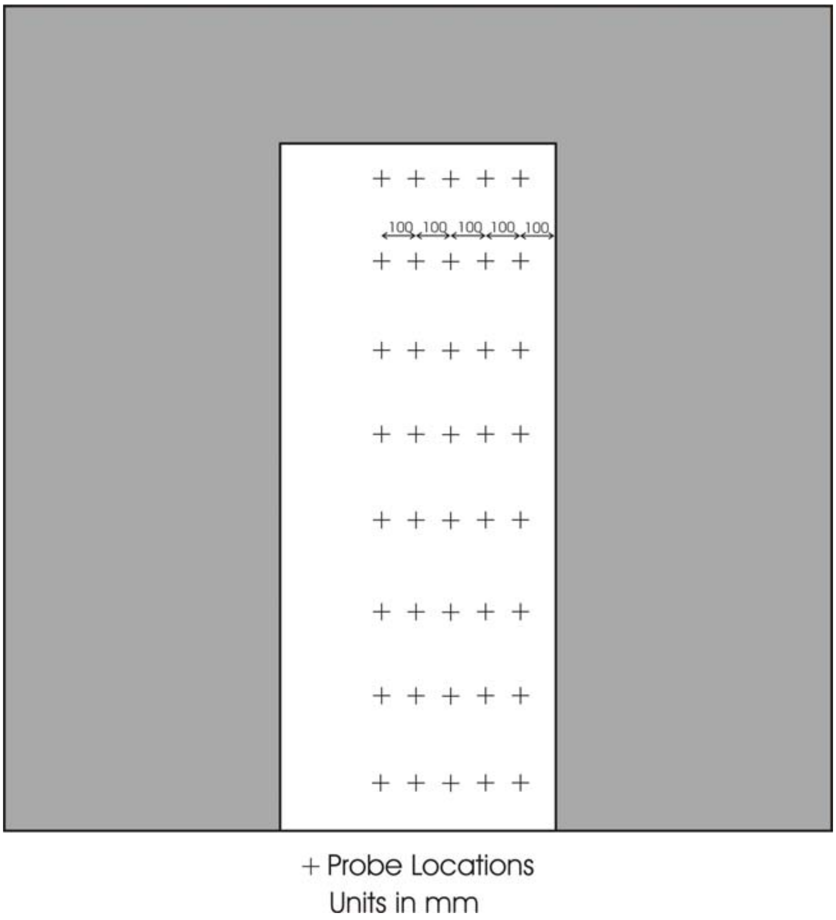

Figure 2.17. The positions in the doorway to which the bi-directional probes are moved during the experiments.

The front opening bi-directional probes are positioned at the centreline of the compartment for both the experiments with the unrestricted opening, and those with the soffit (experiments 00 to 16). In experiments 17 to 22, the doorway has been formed in the front opening. The bi-directional probes in the experiments with the doorway in the front opening are moved to the same positions as the doorway probes. The probes in the front opening are 100mm from the edge of the doorway, for 18 minutes, then 10 minutes at each sample position. Again the thermocouples positioned 50mm from the sample head of the bi-directional probes are moved along with the bi-directional probes.

2.9. Experiment Information

A total of 23 experiments were completed over the period from the 18th of December 2001 to the 29th of January 2002. An overview of these experiments is given in table 2.11. An explanation and diagram for the burner location, front opening and door headings, is given below.

Run #	Date	Fire Size [kW]	Burner Location	Front Opening	Door [°]
00	18/12/2001	120	centre	unrestricted	fully open
01	18/12/2001	120	centre	unrestricted	20
02	21/01/2002	120	centre	unrestricted	60
03	21/01/2002	120	centre	unrestricted	40
04	21/01/2002	120	centre	unrestricted	30
05	22/01/2002	120	centre	unrestricted	fully open
06	22/01/2002	60	centre	unrestricted	fully open
07	22/01/2002	180	centre	unrestricted	fully open
08	23/01/2002	60	corner	unrestricted	fully open
09	23/01/2002	120	corner	unrestricted	fully open
10	23/01/2002	180	corner	unrestricted	fully open
11	24/01/2002	60	back wall	unrestricted	fully open
12	24/01/2002	120	back wall	unrestricted	fully open
13	24/01/2002	180	back wall	unrestricted	fully open
14	25/01/2002	60	centre	soffit	fully open
15	25/01/2002	120	centre	soffit	fully open
16	25/01/2002	180	centre	soffit	fully open
17	28/01/2002	60	centre	door opening	fully open
18	28/01/2002	120	centre	door opening	fully open
19	28/01/2002	180	centre	door opening	fully open
20	29/01/2002	120	centre	door opening	40
21	29/01/2002	120	centre	door opening	30
22	29/01/2002	120	centre	door opening	20

Table 2.11. A summary of the experiments conducted at the McLeans Island test site.

Experiment 00 was an initial run to check all equipment was working correctly.

Burner Location: (See Figure 2.18)

Centre - The burner is in the centre of the fire compartment.

Corner - The burner is in the corner of the fire compartment on the back wall.

Back Wall - The burner is on the centreline of the fire compartment on the back wall.

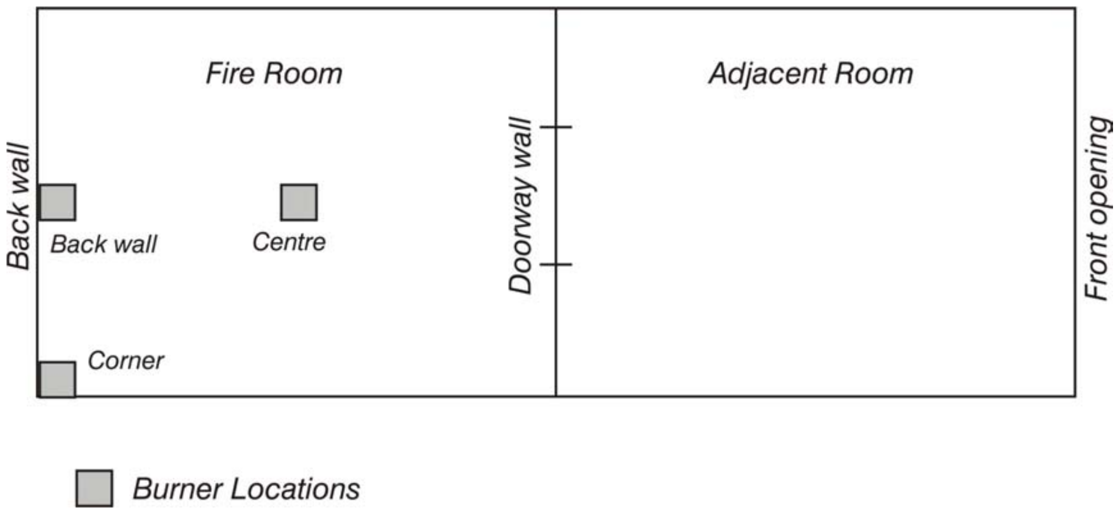

Figure 2.18. A plan view of the burner locations.

<u>Front Opening:</u> (See Figure 2.19)

Unrestricted	- The front opening is the full 2400mm by 2400mm. (Also see figure 2.20).
Soffit	- A soffit (390mm deep) is put in place on the front opening of the compartment. (Also see figure 2. 21).
Door Opening	- A doorway 810mm wide by 2010mm high is formed on the front opening of the compartment. (Also see figure 2.22).

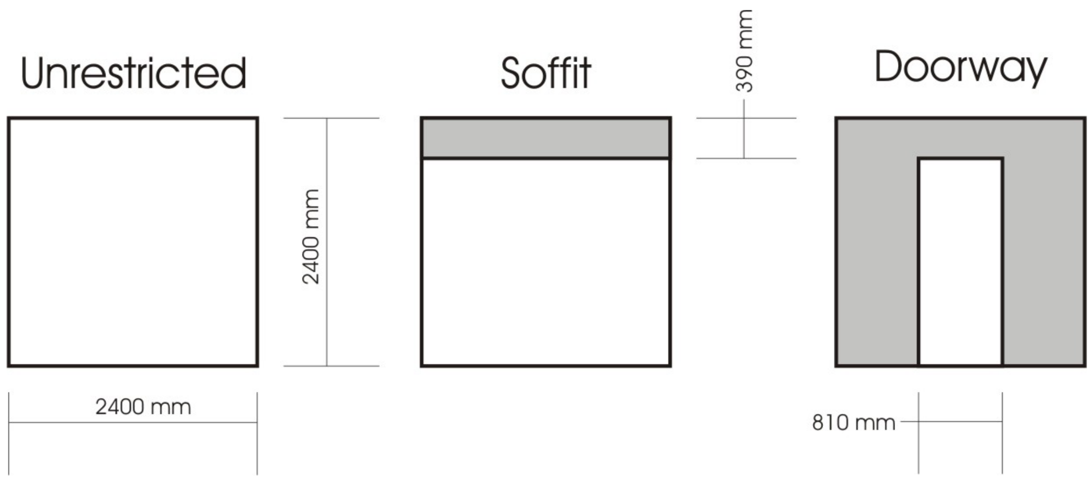

Figure 2.19. Front opening configurations.

Figure 2.20. Front opening of compartment, unrestricted. The Burner can be seen in the corner location for this experiment.

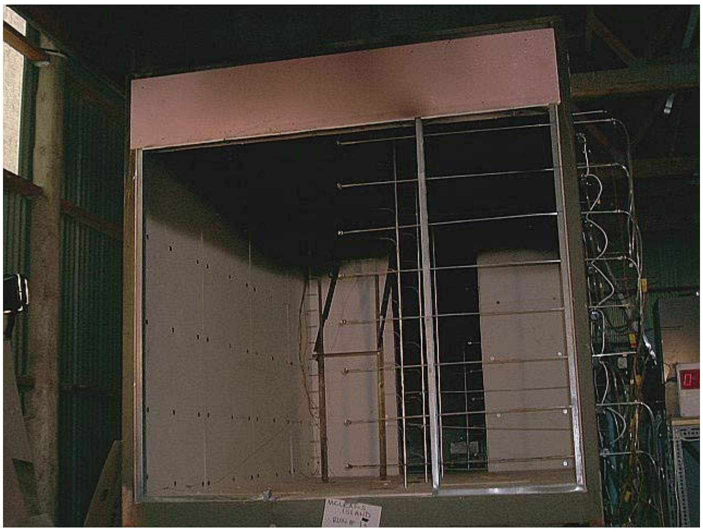

Figure 2.21. Front opening with the soffit in place.

Figure 2.22.Front opening with the doorway on the front opening.

<u>Door:</u> (See Figures 2.22 and 2.23)

Fully Open	- There is no door in place in the doorway.
Angle	- A door is in place, x degrees from fully closed.

The door was used in seven experiments at angles of 20°, 30°, 40° and 60°. The experiments were conducted to investigate the effects of the door angle on fire induced flow through a doorway. Clark, 2002 discusses this further .

Figure 2.23. The door in the doorway, open at 20°.

For the corner and back wall burner locations, experiments 08 to 10 and 11 to 13 respectively, an extra layer of insulation board was placed on the wall and ceiling near the burner. This was one sheet of insulation board placed lengthways on the back wall and side wall for the corner, and one sheet on the middle of the back wall for the back wall burner location. This was done to minimise damage to the gib-board that could result from the high temperatures created from the flame coming in contact with the walls. The insulation was again held in place with screws and washers. The corner burner location with the extra layer of insulation is shown in figure 2.24.

Figure 2.24. Burner in the corner location, with the second layer of insulation board attached.

3. Data Formatting

This chapter gives some background information about the Fire Data Management System, FDMS, and the Extensible Markup Language, XML, and gives details about the conversion of the data from the original format to the final format that the experimental data will be provided in.

3.1. Background Information on Formats

This section provides some background information about the two formats considered.

3.1.1. Fire Data Management System (FDMS)

The Building and Fire Research Laboratory (BFRL) at NIST started to develop a data exchange standard for fire test data. The name Fire Data Management System (FDMS) was given to this standard. The goal for FDMS "is to provide a centralised database of test values generated from a variety of sources within the fire community" (Portier, 1993). "FDMS is a computer database specifically designed to store and retrieve fire test results" (Portier, 1994).

FDMS is aimed at standardised tests such as cone calorimeter, furniture calorimeter and lateral ignition and flame spread tests. There is also the facility for room/corner tests, although the tests conducted at the McLeans Island facility are not standard room/corner tests as specified by the international standard ISO 9705:1993(E). The following paragraph explains the ISO 9705:1993(E) method.

The ISO 9705:1993(E) test is a large scale method for assessing a materials reaction to fire. The test can evaluate properties such as surface flame spread, smoke production, and the production of toxic gases. The ceiling, side walls and rear wall of the compartment are lined with the material to be tested and the experiment is run to a specified test procedure. Since the experiments conducted will not be testing a surface material, the room/corner test method in FDMS is not a suitable format.

FDMS uses a number of field headers, which is either one channel of raw data or one column of reduced data. (A channel denotes a series of readings, corresponding to one physical instrument output, and a column refers to data when reference to hardware channels is not appropriate, such as information about the operator of the experiment). Each header is a multi-line heading, and these are different for reduced and raw data. There are specific headers that can be used for each type of experiment, be it a cone calorimeter test or a room/corner test. The problem with this is that since only specific headers can be used, it is difficult to put the data from a non-standard test setup into this format. Further details of FDMS can be found in the data structure documentation (Portier, 1997). Computing power has dramatically increased since the release of the FDMS format, and it is now probably a little outdated.

3.1.2. Extensible Markup Language (XML)

The World Wide Web Consortium (W3C) defines XML, which is a non-proprietary format that is not subject to copyright, patent, or other type of intellectual property restriction. XML is a metamarkup language that describes a document's structure and meaning. XML is a language similar to HTML, which is commonly used on the world wide web, although it is more flexible than HTML, since there is not a fixed set of tags that define a fixed set of elements as with HTML and FDMS. With XML the tags are made up as they are required, although the tags must still be organised according to general principles. In XML a tag is similar to the header in FDMS, in that it specifies the start of a new set of data, or delimits the data. XML provides a format for describing data by containing a collection of nodes. Each of these nodes contains a pair of tags, one to signify the start and one to signify the end, with the collection of data between these tags. The figure below, figure 3.1, shows two nodes: the time data, and the temperature data. This node also begins and ends with a tag, which is "Experiment1".

```
<Experiment1>
   <Time>0,1,2,3,4,5</Time>
   <Temperature>21,23,21,22,22</Temperature>
</Experiment1>
```

Figure 3.1. Example of a structure of the XML format.

Attributes can also be used inside an XML tag. An attribute consists of the attribute name, an equals sign and the attribute value enclosed in quote marks. For example, figure 3.2 shows the units attribute:

```
<Units = "°C">
```

Figure 3.2. An example of an attribute in XML.

Since XML is non-proprietary and easy to understand, it is a good format for the interchange of data between different applications. There is also no set structure for the document, hence there is more than one way to store the data.

3.2. Data Structures

The data acquired from the experiments at the McLeans Island test facility was provided in a CSV file, which is a comma delimited format, meaning the data is separated by commas. The data was then imported into Microsoft Excel 2000, which puts the experimental data into a spreadsheet form. From here the raw data needed to be converted into appropriate units and converted to an XML file.

Since in the XML format there is more than one way to store the data, a progressive approach to the data formatting has been used.

The first data format that was used was produced by an Excel macro obtained from Inductive Solutions, Inc (Website 1.). This was a program called Excel-to-XML. This program produced data in the format shown below.

```
<TableName>
    <RecordName>
        <RunningTime>0</RunningTime>
        <O2>20.9</O2>
        <CO2>2.1</CO2>
        <CO>0.003</CO>
        <ScaleLPGMass>400</ScaleLPGMass>
        <LPGFlowrate>2.3</LPGFlowrate>
        <Door1>21.1</Door1>
        <Door2>21.0</Door2>
        <Door3>21.2</Door3>
        <Door4>20.9</Door4>
    <RecordName>
<TableName>
```

Figure 3.3. Sample of the data format produced using the program from Inductive Solutions.

This format is rather long-winded, although the structure is very easy to modify and it is easy to exchange information with other programs, since each data element is precisely labelled. The problem with this format is that it requires a large number of characters. It can be seen in figure 3.3 above that each measurement requires the two header tags at each time step. This is called an overhead. This overhead becomes an important consideration in deciding which structure is used due to the large files created and the time required to create the files. The file produced with this macro was too large to be useful, since the experimental data from the McLeans Island fire tests have over 4500 time steps and 200 measurements. Also the program did not easily allow for units or other useful information like instrumentation positions to be included as attributes.

A new approach was then taken. The data would be comma delimited and displayed in one place in the file. This would greatly reduce the overhead and therefore the file size. The second data structure was produced using a macro created in Visual Basic for Applications version 6 (VBA) in Microsoft Excel 2000. A sample output of this is shown in figure 3.4.

```
<Table>
  <measurement name="Ambient Temperature">
      <data type="Time" units="s">0,1,2,3,4,5,6,7,8,9,10</data>
      <data type="Temperature" units="C"
         location="">19.1,19.1,19.2,19.2,19.1,19.1,19.1,19.2,19.1,1
         9.1</data>
    </measurement>
    <measurement name="O2">
      <data type="Time" units="s">0,1,2,3,4,5,6,7,8,9,10</data>
      <data type="O2 Concentration" units="%"
         location="">20.9,20.8,20.9,20.9,20.9,20.9,20.8,20.9,20.9,2
         0.9</data>
    </measurement>
    <measurement name="CO2">
      <data type="Time" units="s">0,1,2,3,4,5,6,7,8,9,10</data>
      <data type="CO2 Concentration" units="%"
         location="">0.36,0.36,0.37,0.36,0.37,0.36,0.36,0.36,0.36,0.
         36</data>
    </measurement>
 </Table>
```

Figure 3.4. Sample of the data format produced using the VBA program written.

Using this format, the ‘data type’ attribute can be used to extract all appropriate data, such as temperature for instance. This would be useful since specific data could be extracted without other data, like gas concentrations, which may be of little use to the person using the information. In this format, data types and units can easily be shown as well as instrumentation locations. The ‘data type’ attribute is used to specify the type of data, be it temperature, O_2 concentration or speed.

The ‘units’ attribute is used for the display of units, and ‘location’ is used to specify instrumentation locations if necessary.

This format also allows for different time scales, but since the data in each XML file will be taken from the same experiment, the time scale for each measurement will be the same. This format produces reasonably compact files, although since the time scales are the same, there is little use in having the time scale repeated for each measurement. The second version of the macro shows the time data only once, at the start of the file.

The VBA program was modified to produce data in the format shown in figure 3.5.


```
<Table>
    <data type="Time" units="s">0,1,2,3,4,5,6,7,8,9,10</data>
  <measurement name="Ambient Temperature">
      <data type="Temperature" units="C"
        location="">19.1,19.1,19.2,19.2,19.1,19.1,19.1,19.2,19.1,1
        9.1</data>
    </measurement>
  <measurement name="O2">
      <data type="O2 Concentration" units="%"
        location="">20.9,20.8,20.9,20.9,20.9,20.9,20.8,20.9,20.9,2
        0.9</data>
    </measurement>
  <measurement name="CO2">
      <data type="CO2 Concentration" units="%"
        location="">0.36,0.36,0.37,0.36,0.37,0.36,0.36,0.36,0.36,0.
        36</data>
    </measurement>
 </Table>
```


Figure 3.5. Sample of the data format produced using the VBA program after the modifications.

This structure also uses attributes to declare the data type and the units like the previous format, although the data is now more compact, since the time data is removed from the measurement header, and therefore smaller files are produced.

A third version of the macro was completed to add two further features. Another header tag was added, being located before the time data. This is the tag "Experimental" and is used to specify experimental setup conditions, date of experiment, and any other details which may be important to the user of the experimental data. A new attribute is also added in the "measurement" tag, which is "Description". This attribute will appear after the measurement name. Under this attribute, any further information such as error details or instrumentation movement details about the measurement will be recorded. Figure 3.6 is a sample of the final structure used.

```xml
<Table>
    <Experimental />
    <data type="Time" units="s">0,1,2,3,4,5,6,7,8,9,10</data>
  <measurement name="Ambient Temperature">
      <Description />
      <data type="Temperature" units="C"
         location="">19.1,19.1,19.2,19.2,19.1,19.1,19.1,19.2,19.1,1
         9.1</data>
    </measurement>
  <measurement name="O2">
      <Description />
      <data type="O2 Concentration" units="%"
         location="">20.9,20.8,20.9,20.9,20.9,20.9,20.8,20.9,20.9,2
         0.9</data>
    </measurement>
  <measurement name="CO2">
      <Description />
      <data type="CO2 Concentration" units="%"
         location="">0.36,0.36,0.37,0.36,0.37,0.36,0.36,0.36,0.36,0.
         36</data>
    </measurement>
```

```
</Table>
```

Figure 3.6. Sample of the final data format produced using the VBA program written.

3.3. Data Conversion

To convert the raw data obtained from the experiments at McLeans Island to the chosen structure in XML, three Visual Basic for Applications programs were written. The first program inserts headings, converts data to the correct units and deletes unused data channels from the raw data. The second program converts the worksheet to the selected XML structure and the third saves the data in the XML format.

The program RawDataConverter was written to automate the conversion of the raw data, which is measured in volts to the appropriate units for each measurement.

The program first converts the recorded time scale to an experimental running time starting from zero. Headings are then pasted into the spreadsheet according to the measurement recorded in each channel of the data file. It then converts the oxygen and carbon dioxide concentrations from a voltage to a percentage based on a calibration constant. Also converted from voltages are the LPG mass, and the LPG flow rate is converted to a heat release rate. Bi-directional probe data is also converted from voltages to speeds.

Any information that needs to be included in the XML file is inserted at this stage. Such information includes information under the experimental tag, and information under any of the description attribute tags.

The format conversion program ChangeFormats was written to convert the experimental data from the Excel spreadsheet created using the first program, RawDataConverter, to the XML format. This is produced as a list of lines in an

Excel worksheet. The ChangeFormats program creates the tags and attributes required to conform with the XML format and outputs these to a worksheet called "Output".

A limitation of the ChangeFormats program as it is written is that the number of rows of data has to be put into the program manually, since each experiment has a slightly different number of time steps. Appendix A contains the code for the visual basic program ChangeFormats.

The third program SaveData takes the "Output" worksheet and saves it as an XML file. The name of this file can be specified in the SaveData program. Appendix A contains the code for the visual basic program SaveData. The experimental data files created from the program will be available on the University of Canterbury Civil Engineering website (http://www.civil.canterbury.ac.nz) from July 2002.

3.4. Nomenclature in the XML Files

- BC = Below Ceiling.
- BS = Below Soffit.
- the value –999 is an error marker, and is found where electronic or other errors have occurred during the recording of the data.
- doorway and front opening heights are specified in this report, since a range of heights is given due to the movement of the probes, and therefore thermocouples, during the experiments.

3.5. Further Work

To view the XML files created, Microsoft Internet Explorer version 5.0 (IE) is used. Currently the data shown by IE is truncated. This may be due to constraints on the memory available. This is only a display problem however, since when the data is copied from the XML file, all of the data is present. Since XML describes the structure of the document, not the format of the information, a separate style sheet needs to be written to display the data on the world wide web. Experimental data from other fire experiments conducted should also be converted to the XML format and be readily available on the web.

4. Results

There was a large amount of data collected from the experiments conducted at the McLeans Island test site and describing all of this data in this report is not feasible. In this section typical results are shown using the data from experiment 5. This experiment has a heat release rate of 120kW, the burner is located in the centre of the fire compartment, no door is present in the central doorway and the front opening of the two-room compartment is unrestricted.

4.1. Temperature

Figure 4.1 shows the time-temperature plot for the doorway joining the fire compartment to the adjacent compartment. As explained in section 2.8 the thermocouple position changes during the experiment. The figure next to the graph shows the positions as would be seen looking into the fire compartment from the adjacent compartment. Not all of the doorway thermocouples are shown in this graph for reasons of clarity. It is interesting to note the increase in temperature when measuring temperature at position 1 for the period from 3780s. This is an increase of about 10°C for the top four thermocouples in the doorway.

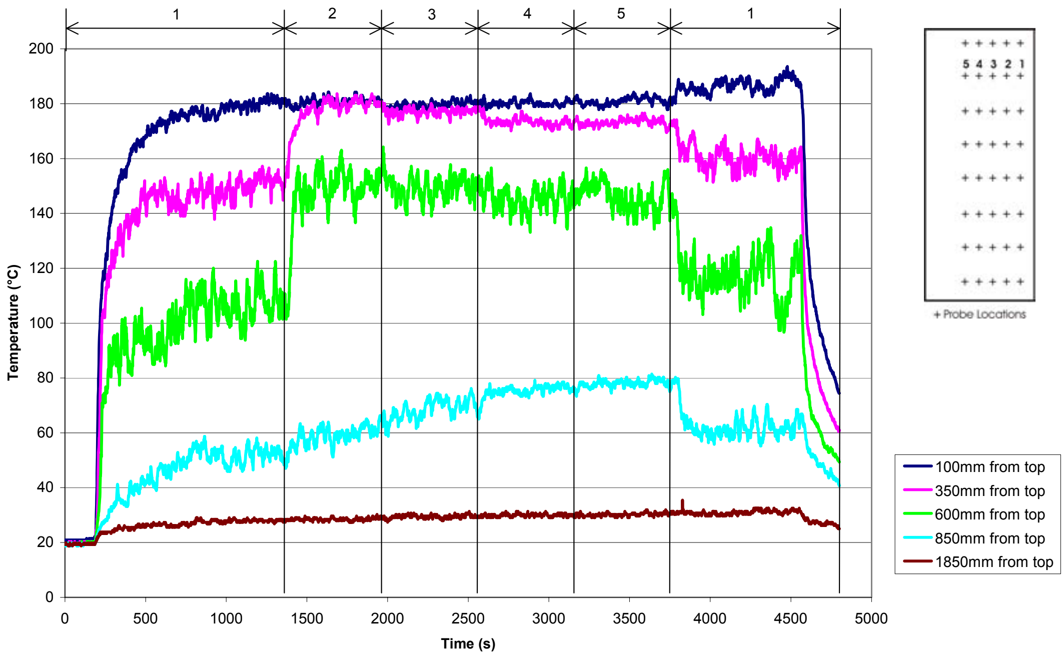

Figure 4.1. Time-temperature plot for the doorway.

Figure 4.2 shows the temperature in the fire compartment at thermocouple tree #1. The thermocouple at 1000mm below the ceiling (BC) has a wide range of temperatures which shows that this thermocouple is near the neutral plane. The ceiling and floor temperatures show that there is a slow increase in temperature in the fire compartment throughout the experiment.

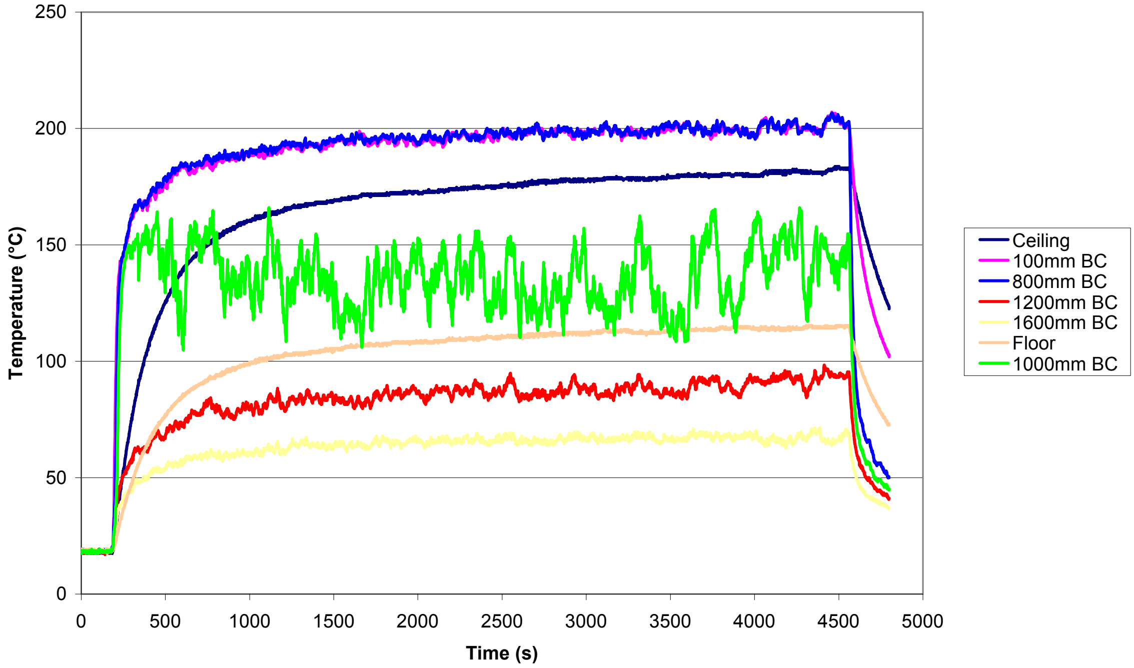

Figure 4.2. Time-temperature plot for thermocouple tree #1.

Average temperatures over the duration of the experiment excluding the 'start-up' and 'shutdown' periods, the first 13 minutes and last 4 minutes respectively, are given in tables 4.1 and 4.2. Table 4.1 summarises the temperatures from the thermocouple trees located on the centreline of the compartment. Figure 4.3 shows the positions of the thermocouple trees in relation to the burner.

Distance below ceiling (m)	TC Tree #1	TC Tree #2	TC Tree #3	TC Tree #4	TC Tree #5	TC Tree #6	TC Tree #7
Ceiling	174	187	202	195	127	113	92
0.05	195	203	210	204	159	138	117
0.1	196	204	210	204	155	115	107
0.2	199	202	208	194	137	91	95
0.3	199	201	209	189	96	79	83
0.4	200	200	209	185	62	68	72
0.6	199	197	214	178	34	32	30
0.8	196	195	219	175	31	34	28
1	135	167	223	155	31	31	26
1.2	87	102	243	123	27	28	25
1.4	70	81	339	96	27	29	25
1.6	65	75	429	84	28	28	24
1.8	67	66	523	71	28	29	23
2	61	63	662	49	26	27	24
2.2	66	59	52	32	26	27	23
Floor	109	124	78	150	55	48	40

Table 4.1. Average temperatures for the thermocouple trees located on the centreline of the compartment.

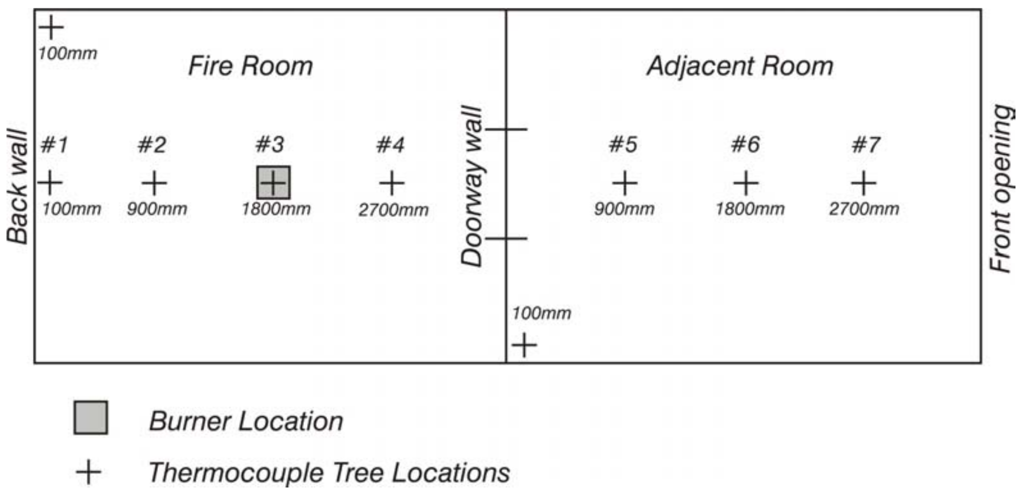

Figure 4.3. Thermocouple tree locations as measured from the back wall.

Distance below ceiling (m)	Corner of Fire room	Corner of Adjacent room	Distance below ceiling (m)	Front opening	Distance below door soffit (m)	Doorway
0.1	197	115	0.25	79	0.105	181
0.25	199	107	0.475	31	0.35	167
0.4	200	75	0.735	27	0.605	134
0.55	200	29	0.98	26	0.85	66
0.7	200	27	1.235	25	1.1	45
0.85	197	24	1.49	26	1.365	37
1	171	24	1.76	25	1.61	33
1.15	97	24	2	24	1.86	30
1.3	80	25				
1.45	67	24				
1.6	67	24				
1.75	70	23				
1.9	63	24				
2.05	63	23				
2.2	67	23				
2.35	73	24				

Table 4.2. Average temperatures for the thermocouple trees in the corners of the fire compartment and adjacent compartment, and for the doorway and front opening of the compartment.

Figure 4.4 shows the temperature 0.3m below the ceiling as a function of distance from the back wall of the compartment. The temperature peaks at 1.8m since these thermocouples are directly above the burner and are in the flames. The data is from different times during the experiment, 200s, 240s, 300s, 600s, 3000s and 4000s from the start of the experiment. Ignition of the burner occurs at 182s for this experiment. This shows the change in temperature as a function of time.

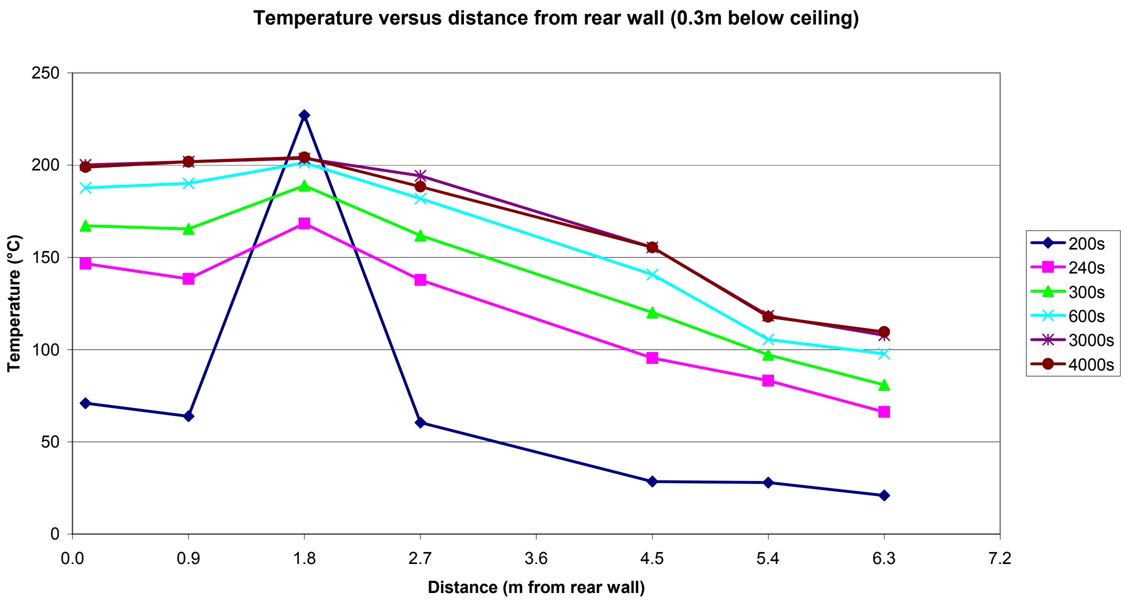

Figure 4.4. Temperature against distance 0.3m below the ceiling.

4.2. Gas speed

The gas speed was measured in the doorway, in the front opening of the compartment, and in the adjacent compartment 100mm below the ceiling on thermocouple trees 5 and 7. As explained in section 2.8, the bi-directional probes are moved during the experiment. This is done to see how the speed of the gas flow changes across the width of the doorway. The bi-directional probe was located at position 1 for the 13 minute 'start-up' period and then 10 minutes at each measurement location, positions 1-5. It was then moved back to position 1, where it stayed for the rest of the experiment. Figure 4.5 shows the gas speeds through the doorway with respect to time. A negative speed means the flow is out of the fire compartment, while a positive speed means the flow is into the fire compartment. The graph shows that the gas speeds are highest closest to the edge of the doorway, i.e. positions 1 and 2.

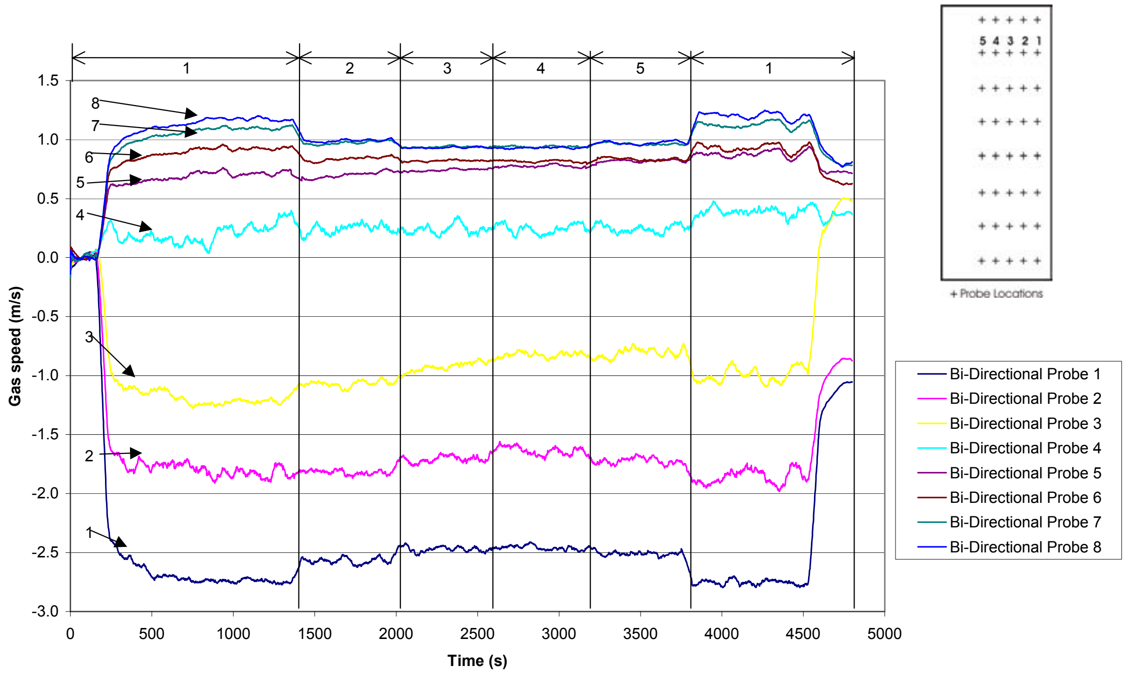

Figure 4.5. Gas speeds through the doorway connecting the fire compartment and the adjacent compartment.

4.3. Gas concentration

Oxygen and carbon dioxide concentrations were measured in the compartments during the experiments. This was done by measuring at a number of locations in the two-room compartment. As explained in section 2.8 the position measuring the species concentration was changed every 3 minutes, after a period of 8 minutes measurement of ambient conditions and a 5 minute period sampling at position 13, the topmost measurement probe in the doorway. Figure 4.6 shows the species concentrations as a function of time. Sampling locations are also shown in this figure. The sketch next to the graph indicates the positions where species measurement occurred. More precise measurement locations can be found in section 2.7. The maximum carbon dioxide concentration measured was at position 1, with a CO_2 concentration of about 1.2%. The lowest oxygen concentration occurred at this same position, the oxygen level dropping from 20.95% at ambient conditions to 19.2%.

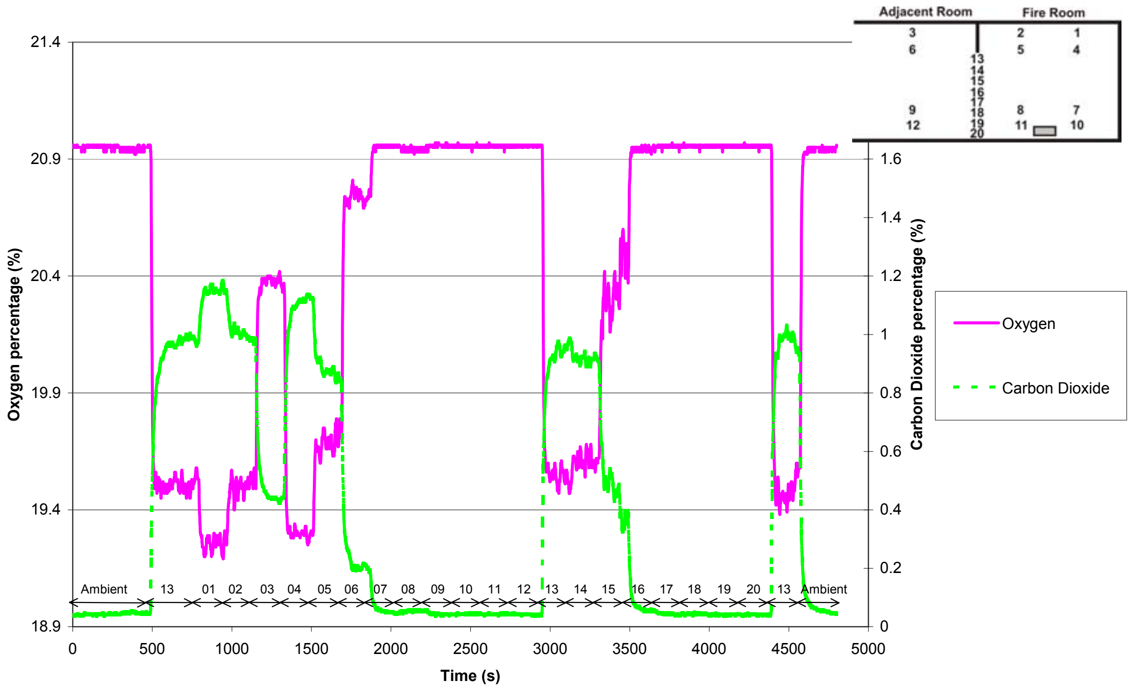

Figure 4.6. Gas concentrations measured throughout the experiment.

Table 4.3 shows the average concentrations of oxygen and carbon dioxide measured at each measurement location. The average is calculated over the last 2 minutes of the sampling period. The consistency in the values measured at location 13 show the repeatability in the sampling.

Location	O_2 (%)	CO_2 (%)
Ambient	20.9	0.05
13	19.5	0.99
1	19.3	1.15
2	19.5	1.00
3	20.4	0.44
4	19.3	1.11
5	19.7	0.87
6	20.7	0.21
7	21.0	0.05
8	20.9	0.05
9	21.0	0.04
10	21.0	0.04
11	21.0	0.04
12	21.0	0.04
13	19.5	0.94
14	19.6	0.91
15	20.4	0.44
16	20.9	0.06
17	21.0	0.04
18	21.0	0.04
19	21.0	0.04
20	21.0	0.04
13	19.5	0.99
Ambient	20.9	0.06

Table 4.3. Average oxygen and carbon dioxide concentrations for each measurement location.

5. Conclusions

The experiments conducted at the McLeans Island test facility were carried out from the 19th of December 2001 to the 29th of January 2002. A total of 23 experiments were completed during this time. The experiments were conducted to assist in the validating of computer modelling of fires in an enclosure. The results from these pre-flashover fire experiments is an extensive set of data with a wide variety of measurements. Complex room geometries are represented in the data, with the existence of an adjacent room with various openings to the ambient surroundings. This means the data will have a considerable number of uses.

Fire test data needs to be shared within the fire community and needs to be easily accessible. The world wide web is an excellent medium for this data exchange. Due to the large size of the data files resulting from the experiments, a format is needed that produces smaller files, without diminishing the value of the data. The format should also be easily displayed on the web.

Two formats were considered for this purpose, FDMS and XML. XML was chosen as the format that the fire test data would be stored in. XML is a metamarkup language that is used to describe the structure and meaning of a document. It is a good format for data storage since it is not limited by specific field headers, which means any type of data can be stored. FDMS has a specific set of headers that can be used for standard fire tests, which makes it difficult to store non-standard test data. The XML format was selected since it is very flexible and can easily be placed on the world wide web for widespread availability.

XML is becoming increasingly used as a method of data storage and retrieval in several engineering fields and is likely to have an influence on the fire engineering field. The existence of an easy to understand format for fire test data that is readily displayed on the web allows for the exchange of this data within the fire engineering community. The exchange of experimental test data should be encouraged as it will improve of our understanding of fire behaviour.

6. References

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Websites

(1) www.inductive.com

(2) www.freevbcode.com

Appendix A

The appendix contains the Visual Basic for Applications (version 6) code for the two programs used to convert and save the data in the XML format.

The ChangeFormats Program

```
Option Explicit

Public Sub Changeformats()
' This program was written by Luke Rutherford, 2002.
' This program converts the data obtained from the experiments
' at the McLeans Island testing site in 2001-2002 to the XML format.

Dim sTime As Single, sTemp As Single, sData As Single
Dim sRows As Single
Dim l As Long, lNumrngData As Long, lColumn As Long
Dim rngCell As Range, rngName As Range, rngOutput As Range
Dim rngUnits As Range, rngLocation As Range, rngType As Range
Dim rngData As Range, rngTime As Range, rngDescription As Range
Dim stDate As String, str As String, strInt As String
Dim stActwb As String, stActsh As String, stOutputsheet As String
Dim stType As String, stTimeUnits As String, stTime As String
Dim stUnits As String, stLocation As String, stName As String
Dim stDescription As String
Dim iTitle As Integer, iNumTitle As Integer, iCounter As Integer
Dim lNum As Long, lNumData As Long, lColumnNum As Long
Dim iNumrngTitle As Integer

lNum = 1
stActwb = ActiveWorkbook.Name
stActsh = ActiveSheet.Name
stOutputsheet = "Output"

' sRows = the number of rows of data
sRows = 4355
```

```
stDate = "Table"
stTimeUnits = "s"
stTime = "Time"
Set rngTime = Workbooks(stActwb).Sheets(stActsh).Range("B10:B4355")
Set rngCell = Workbooks(stActwb).Sheets(stActsh).Range("C5:GQ4355")
Set rngName = Workbooks(stActwb).Sheets(stActsh).Range("C5:GQ5")
Set rngType = Workbooks(stActwb).Sheets(stActsh).Range("C6:GQ6")
Set rngUnits = Workbooks(stActwb).Sheets(stActsh).Range("C7:GQ7")
Set rngLocation = Workbooks(stActwb).Sheets(stActsh).Range("C8:GQ8")
Set rngDescription = Workbooks(stActwb).Sheets(stActsh).Range("C9:GQ9")
Set rngData = Workbooks(stActwb).Sheets(stActsh).Range("C10:GQ4355")
Set rngOutput = Workbooks(stActwb).Sheets(stOutputsheet).Range("A1")

' iTitle = the number of columns of data
iTitle = 197
lColumnNum = 1

    lNumrngData = rngData.Count
    iNumrngTitle = rngName.Count
    iNumTitle = iNumrngTitle / iTitle
    lNumData = lNumrngData / iNumTitle

'  Setup output columns
    With rngOutput
    l = 1
    .Cells(1, 1) = "<?xml version ='1.0' ?>"
    .Cells(l + 1, 1) = "<" & stDate & ">"
    iCounter = 1
    str = ""
    .Cells(iCounter + 2, 1) = "<Experiment>  </Experiment>"
    For lNum = 1 To sRows
        Call getTimeData(rngTime, lNum, sTime)
        If lNum = sRows Then
            str = str & sTime & "</data>"
        Else
            str = str & sTime & ","
        End If
    Next lNum
    .Cells(iCounter + 3, 1) = "<data type='" & stTime & "' units='" & stTimeUnits & "'> " & str
```

```
'For loop numbers to the total number of Data Columns
For l = 1 To 197
   lNum = l
   Call getName(rngName, lNum, stName)

   lNum = l
   Call getType(rngType, lNum, stType)
   Call getUnits(rngUnits, lNum, stUnits)
   Call getLocation(rngLocation, lNum, stLocation)
   Call getDescription(rngDescription, lNum, stDescription)

   strInt = ""
   lColumnNum = 1 * l
   .Cells(iCounter + 4, 1) = "<measurement name ='" & stName & "'>"
   .Cells(iCounter + 5, 1) = "<Description>" & stDescription & "</Description>"
   For lNum = 1 To sRows
      Call getData(rngData, lColumnNum, lNum, sData)
      If lNum = sRows Then
         strInt = strInt & sData & "</data>"
      Else
         strInt = strInt & sData & ","
      End If
      lColumnNum = (lColumnNum + 197)
   Next lNum
   .Cells(iCounter + 6, 1) = "<data type='" & stType & "' units='" & stUnits & "' location='" &
stLocation & "'> " & strInt
   .Cells(iCounter + 7, 1) = "</measurement>"
   iCounter = iCounter + 4
Next l
   ' Used to finish XML sheet
   .Cells(iCounter + 4, 1) = "</" & stDate & ">"
   End With

End Sub

Function getType(getrange, lNum, stType)
   Dim l As Integer
   l = lNum
   stType = getrange.Cells(l)
End Function
```

```
Function getData(getrange, lColumnNum, lNum, sData)
    sData = getrange.Cells(lColumnNum)
End Function

Function getTimeData(getrange, lNum, sTime)
    Dim l As Long
    l = lNum
    sTime = getrange.Cells(l)
End Function

Function getUnits(getrange, lNum, stUnits)
Dim l As Integer
     l = lNum
      stUnits = getrange.Cells(l)
End Function

Function getLocation(getrange, lNum, stLocation)
     Dim l As Integer
     l = lNum
     stLocation = getrange.Cells(l)
End Function

Function getDescription(getrange, lNum, stDescription)
    Dim l As Integer
    l = lNum
    stDescription = getrange.Cells(l)
End Function

Function getName(getrange, lNum, stName)
    Dim l As Integer
    l = lNum
    stName = getrange.Cells(l)
End Function
```

The SaveData program.

```
Option Explicit

Function SaveData()
' This program was written by Luke Rutherford, 2002.
' This program saves the data obtained from the experiments
' at the McLeans Island testing site in 2001-2002 to the XML format.

Dim lNum As Long, lColumnNum As Long
Dim str As String, stData As String
Dim stActwb As String, stActsh As String
Dim sTime As Single, sData As Single
Dim rngCell As Range

stActwb = ActiveWorkbook.Name
stActsh = ActiveSheet.Name
Set rngCell = Workbooks(stActwb).Sheets(stActsh).Range("A1:A793")

Open "TestFile19.xml" For Output As #1

For lNum = 1 To 793
   Call getCellData(rngCell, lNum, stData)
   str = stData
   Print #1, str
Next lNum

Close #1
End Function

Function getCellData(getrange, lNum, stData)
   stData = getrange.Cells(lNum)
End Function
```