# COMPARISON OF FLAME SPREAD MEASUREMENTS USING THE ASTM E 1321 LIFT AND A REDUCED SCALE ADAPTATION OF THE CONE CALORIMETER APPARATUS

BY

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## Abstract

A full-scale ASTM E 1321 Lateral ignition and Flame Transport (LIFT) apparatus was constructed and compared with a Reduced scale Ignition and Flame spread Test apparatus (RIFT) adaptation of the cone calorimeter in the vertical position. The objective was to find a low cost and simple alternative to the LIFT apparatus for measuring opposed flow flame spread.

Ignition tests were conducted using the LIFT, RIFT and ISO 5657 ignitability apparatus and flame spread experiments were conducted in the LIFT and RIFT. Nine different types of timber based products were tested for ignition and flame spread, and Quintiere's flame spread model was applied to the results to obtain material properties, such as thermal inertia, flame spread parameter and the minimum heat flux required for flame spread. These materials included plywood, medium density fibreboard (MDF), hardboard, particle board flooring, Melamine (Melteca) covered MDF, New Zealand Rimu, and Beech and New Zealand grown Macrocarpa and Radiata (Monterey) Pine. Further limited tests were conducted on Melteca covered particle board, and a second brand of particle board. The materials in the RIFT were tried with and without preheating to equilibrium. In addition, a view factor for the RIFT was developed, based on earlier work for the cone calorimeter element. The view factor equation was experimentally tested against measured values, and the calculated value was consistently lower than the experimental values, with similar flux profile.

The standard procedure is for the material to be preheated before ignition, so that the surface is at equilibrium. The spread of the flame front past points on the sample surface after ignition is recorded, and from the flame front velocity and the model by Quintiere, material specific properties can be derived. The lack of preheating was found to affect the final results, by reducing the flame spread velocity and increasing the scatter in the experimental results.

The RIFT gives comparable results to the same materials tested in the LIFT and to the published literature. The results the flame spread parameter and the minimum flux for flame spread are usually higher for the RIFT against the same material in the LIFT.

There proved to be an effective limit on suitable materials able to be successfully tested in the RIFT to those that have a minimum flux for flame spread of less than 7kW/m$^2$, with this limitation is dictated by the flux profile along the sample, and the lower resolution dictated by the smaller size. It is approximately equivalent to a minimum ignition flux of 18kW/m$^2$.

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## Mathematical symbols

| *Symbol* | *Name* | *Units* |
|---|---|---|
| $b$ | Ignition parameter | $s^{-½}$ |
| $Bi$ | Biot number | - |
| $c$ | Specific heat | J/kgK |
| $C$ | Flame spread modulus | $m^{3/2}/kWs^{½}$ |
| $D$ | Thermal penetration depth | m |
| $Fo$ | Fourier number | - |
| $h$ | Heat transfer coefficient | $kW/m^2K$ |
| $k$ | Thermal conductivity | kW/mK |
| $k\rho c$ | Thermal inertia | $(kW/m^2K)^2s$ |
| $\dot{q}''$ | Heat flux | $kW/m^2$ |
| $t$ | Time | s |
| $t^*$ | Time for thermal equilibrium | s |
| $T$ | Temperature | °C |
| $V$ | Velocity | m/s |
| $x$ | Distance along sample | mm |
| | | |
| $\alpha$ | Thermal absorptivity | - |
| $\delta$ | Length heated in front of flame | m |
| $\varepsilon$ | Emissivity | - |
| $\Phi$ | Flame spread parameter | $kW^2/m^3$ |
| $\rho$ | Density | $kg/m^3$ |
| $\sigma$ | Stefan- Boltzmann constant | $5.67x10^{-8}\ kW/m^2K^4$ |

| | | |
|---|---|---|
| $\theta$ | Angle between sample and element | ° |

*Subscripts*

| | |
|---|---|
| crit | Critical ignition value |
| c | Convective |
| e | Incident on surface |
| f | Flame |
| ig | At ignition |
| min | Minimum value |
| r | Radiative |
| peak | Peak value |
| s | Required for flame spread |
| surf | Surface |
| t | At *t* seconds |
| xmm | Measured at the x mm position on the sample |
| ∞ | Ambient |

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This report is dedicated to my son Robert.

# 1 Introduction

## *1.1 The history of flame spread testing*

The study of flame spread along the surface of materials is a key part to fire modelling and prediction of fire behaviour. It forms the underlying basis for many predictions of flashover and room fire growth (Cleary and Quintiere, 1991).

It has long been recognised that the rate of flame spread on the surface is an indication of how quickly conditions in a compartment become hazardous. As a result, most building codes require building surfaces to meet minimum flame spread requirements, and the failure to do so has resulted in tragic fires in the past. A well known example is the Stardust Disco fire in Dublin in 1981, which killed 48 people. The wall linings of an alcove were lined with flammable carpet tiles, and the fire rapidly spread once they ignited. (Rasbash, et al 2004). Most of the code requirements are based on an index figure, based on the performance in a test. The formulation of the index, and what is considered to be "acceptable" performance is largely arbitrary and of little use for further modelling or comparison to other standards. A typical example of this is the ASTM E 84 "tunnel test" where the flame spread over a surface is given an index value depending on the performance of the material compared with red oak (Janssens, 2005). Such a result allows ranking compared with other materials tested in the same manner, but cannot be easily compared with results from other jurisdictions which have different test methods, and the results cannot also be further developed to give an estimate of the fire behaviour when the material is in use. The wide variety of standards increases the cost and space required in the laboratory, and this is made worse by the fact that many of the tests are similar, but specific to certain materials and situations.

There has been a focus on moving to standardised tests, which achieve the objectives of previous test standards, but which can provide data for modelling fire behaviour. This has largely arisen since the development of the ASTM E 1354 cone calorimeter, which has allowed the development of equivalency correlations to previous test methods.

The research in this report is specifically on the study of lateral flame spread. This is also known as creeping or opposed flow flame spread, and covers the case where the

flame front is moving perpendicularly or against the airflow direction, so that the flame front does not extend over the unburnt material. The airflow is generally buoyancy driven flow, driven by the heat from the fire. The flame spread in this direction is typically in the order of 100 times slower than the case where the flame front is moving in the direction of the fire (Quintiere, 2002) , and hence is less of a concern to life safety in the early stages of fire growth.

The protocol which is covered by this research is the Lateral Ignition and Flame Transport (LIFT) test, adopted as the ASTM E 1321 standard. It gives apparent material properties which can be used in modelling fire growth on a surface (Cleary and Quintiere, 1991). These properties include:

- Thermal inertia $k\rho c$;
- The minimum heat flux for ignition $q''_{ig,\min}$ and the resulting minimum surface temperature for ignition, $T_{ig}$
- The minimum heat flux for flame spread $\dot{q}''_s$ and the resulting minimum surface temperature for flame spread, $T_s$
- A material property called the flame spread parameter $\phi$ which will allow the calculation of the flame spread rate for a material, if the incident heat flux and material properties are known.

## *1.2 Research objectives*

The LIFT apparatus, which forms the basis of the lateral flame spread measurements in the ASTM E 1321-97a standard is bulky, with a footprint of approximately 1.7x0.9m, and requires a gas and compressed air supply for a radiant gas panel.. The numbers of LIFT testing facilities in the world is limited, due to the limited scope of the test. In comparison, the ASTM E 1354 cone calorimeter is the cornerstone of modern fire testing, forming the basis of much of the research into material properties, and hence many of the legislative requirements for materials. Within 10 years of the cone calorimeter being available commercially, nearly 100 were in worldwide service (Babrauskas, 1995). There are at least 3 cone calorimeters in New Zealand, at the University of Canterbury, Building Research Association of New Zealand (BRANZ)

and Canesis - formerly the Wool Research Organisation of New Zealand (WRONZ). By comparison, Babrauskas (1995) put the number LIFT testing facilities in the world at 20 in 1995.

In addition, the time for ignition testing in the cone calorimeter is significantly less than that of the LIFT, with the test duration approximately half as long (Babrauskas, 1999). The thermocouple control of the cone element also give more consistent performance than is achievable than the gas panel used in the LIFT.

Finally, the RIFT and cone calorimeter use smaller sample sizes than the LIFT, allowing more tests to be conducted with a given amount of material.

The cone calorimeter has been shown to give good predictions of fire and test performance for materials, electrical cabling, compartment flashover and a wide variety of other parameters. Efforts to apply cone calorimeter data to modelling lateral flame spread have had limited success (Gorranson, 1992).

Initial research at FireSERT at the University of Ulster developed the Reduced scale Ignition and Flame spread (RIFT) apparatus, which showed some success. This used the cone calorimeter as the heat source for flame spread testing, in the same manner as the LIFT. Application of the flame spread procedures and theory, developed by Quintiere (1981, 1983, 1984) in the ASTM E 1321 standard gave the flame spread parameter $\Phi$, not otherwise obtainable from cone calorimeter data. Further work at the University of Newcastle by Pease (2001) and Huynh (2003) was inconclusive due to the experimental apparatus. In all cases, the RIFT results were compared with data previously published in the literature, and not directly against LIFT tests of the same material.

The objectives of this report can be summarised as

- To manufacture and calibrate a full scale LIFT apparatus at the University of Canterbury for the use in this report, and to identify improvements for future research.
- To manufacture and calibrate a RIFT attachment for the cone calorimeter and apply the flame spread theory developed for the LIFT by Quintiere to the results.

- To directly compare the results from the RIFT with the same materials tested in the LIFT, to eliminate a variable in the results. If the research is successful then this will allow laboratories with only the cone calorimeter to derive flame spread properties without new equipment.
- As part of the RIFT research, the development of a view factor for the RIFT, previously developed by Huynh (2003), is to be continued to see if the shortcomings identified in the earlier research can be corrected.

The results that will be compared between the two testing methods include:

- The minimum ignition flux $\dot{q}''_{ig,\min}$ for ignition tests in the LIFT, RIFT and ISO 5657 ignitability apparatus
- The thermal inertia value, $k\rho c$ from the ignition results
- The minimum flux for flame spread $\dot{q}''_{s}$ for LIFT and RIFT tests
- The flame spread parameter, $\Phi$

Where information in the literature is known, then the values will be compared with previously published data.

### *1.3 Materials chosen*

Nine wood based materials were used in the series of tests conducted for this report, with some limited tests conducted on variations of these materials. Most New Zealand manufactured timber based products are Radiata Pine based, as this is the most common species grown in New Zealand. The materials chosen for the tests in this report were based on the availability of previously published data, particularly Huynh (2003) and Azhakesan et al (1998). A secondary objective was to provide some information on New Zealand materials which was otherwise not available.

The thickness of the natural timbers used in the RIFT was less than the samples used in the LIFT due to difficulties in inserting the thicker samples into the sample holder.

| *Material* | *Manufacturer and trade name* | *Description* | *Thickness (mm)* | *Density of tested samples ($kg/m^3$)* |
|---|---|---|---|---|
| Plywood | IPL "Tuffply" | C/D grade untreated radiate Pine | 17 | 487 |
| Particle board (chipboard) | Laminex Corp (Fletcher Wood Panels) "Pynefloor"<br><br>Laminex Corp (Fletcher Wood Panels) "Superflake" | Radiata Pine based flooring particle board.<br><br>Radiata Pine based particle board. | 20<br><br>20 | 745<br><br>673 |
| Medium density fibreboard (MDF) | Fletcher Wood Panels "Customwood" | Radiata Pine based standard MDF. | 18 | 620 |
| Melteca faced medium density fibreboard<br><br>Melteca faced particle board | Laminex Corp (Fletcher Wood Panels) Melteca<br><br>"Regal" pre - finished shelving | White Melamine faced MDF<br><br>White Melamine pre - finished and clashed shelving from builders merchants | 18<br><br>18 | 681<br><br>661 |
| Hardboard | Unbranded | Hardboard fibreboard | 5 | 819 |
| NZ Radiata Pine (Monterey Pine) | | Clear grade, kiln dried and untreated | 16 (RIFT)<br>20 (LIFT) | 425 |
| NZ Macrocarpa | | Clear grade, | 16 (RIFT)<br>20 (LIFT) | 514 |
| NZ Rimu | | Heart grade | 16 (RIFT)<br>20 (LIFT) | 660 |
| NZ Beech | | | 16 (RIFT)<br>22 (LIFT) | 489 |

**Table 1: Materials tested**

Particle board is made from wood chips held together with a pressure cured adhesive. It is commonly used for flooring and as a substrate for kitset furniture.

Two boards of the same nominal type were tested. Both boards are made by the same company – the Laminex division of Fletcher Wood Panels and are Radiata Pine based, with the Pynefloor having a higher density than the Superflake board used in these tests. According the Material Safety Data Sheets provided for both materials, as the flooring material is expected to be exposed to the weather during construction, a different adhesive is used. The Pynefloor uses a polymerised urea formaldehyde adhesive (up to 15% of the board content) (MSDS Pynefloor 2004), to give weather resistance for up to 8 weeks of exposure, whereas Superflake uses a melamine urea formaldehyde adhesive (up to 13% of the board content (MSDS Superflake, 2004)), and is for internal use only

Medium Density Fibreboard (MDF) is a panel product frequently used for cabinetry. It is made from wood fibre, which is exploded with steam before being compressed with a pressure cured adhesive to form a flat, stable wood panel (Youngquist, 1999). The term "fibreboard", used in the literature is often poorly defined and the density and properties of fibreboard products can vary greatly depending on the end use and manufacturing process. While "fibreboard" may refer to MDF, it may also refer to low density fibreboards, of the type commonly used for pinboards and ceiling tiles. As such, the material properties will be different from MDF and will give different test results.

Plywood is made from layers of wood, with the grain direction of each ply at 90 degrees to the neighbouring plies, and the layers are joined with a pressure cured adhesive. The grade used for these tests is C/D grade, commonly used for construction. One face is sanded and surface knots are secure or filled. The other face is rough and empty knots are allowed.
Plywood can have varying properties, depending on the substrate and surface plies used and the presence of any voids in the material.

Hardboard is a compressed fibreboard sheet product, made from wood pulp and fibres, which is exploded with pressure and steam, similar to MDF and this is then compressed using a thermosetting adhesive to form a thin, high density board (Youngquist, 1999), with a characteristic brown colour. It is commonly used for low

strength applications such as cupboard backs and drawer bottoms. A common brand name which is often used as a generic name for this type of hardboard is Masonite.

Melteca consists of melamine facing on a substrate of either MDF or particle board. It is commonly used for shelving, kitchen cabinets, cupboards and bench tops. Two brands of Melteca faced board were tested, where one uses a MDF substrate, and the other uses particle board.
The manufacturer of each board was different so some variation in the performance of the samples due to the differences of the facing material is expected.

Macrocarpa (Cypresses Macrocarpa**)** is a member of the cypress family, and is also known in the US as Monterey cypress. It has the typical cypress smell to it, which is especially noticeable when it burns. The timber is used for boat building, furniture, framing and panelling. It is known for the wild grain and knotty timber it produces, and can be resinous. It is prone to sparking when burning due to the resin pockets.

Radiata Pine is a native of California, and is also known there as Monterey Pine. It forms the basis of New Zealand silviculture, making up 95% of the New Zealand timber production in 2004 (anon, MAF statistics, 2005). It forms the basis of almost all New Zealand made framing timber and manufactured wood panels.

Rimu is a native New Zealand timber, although other members of the same family are found through the Pacific Rim. It is best known for the dramatic grain of the heart timber and reddish brown colour, although the other Rimu species from the Pacific, principally Fiji and sold in timber suppliers as Pacific Rimu, tends to be plainer and have a lower density. The colour and density varies between the sap wood, and the heart wood. The sap wood and late growth timber tends to be a plain brown and prone to borer infestation.
It has been widely used for flooring, panelling and furniture making, and was widely used for framing until the introduction of Radiata Pine from the 1960s.

# 2 The theory of flame spread

Flame spread is divided according to the direction of any forced or buoyancy driven flow in regard to the direction of flame travel. In the case of wind assisted or vertical flame spread, the flame extends over the unburnt area, increasing the area affected by the radiation from the flame and hence the preheating of the material. Opposed flow (also called creeping or lateral flame spread) is where the flame is either over the already burnt material or at right angles to it (Figure 1)., so that there is no flame extension over the unpyrolised area The LIFT test, and hence the RIFT test, is concerned with opposed flow flame spread. The theory and principles of opposed flow flame spread is developed later in 2.

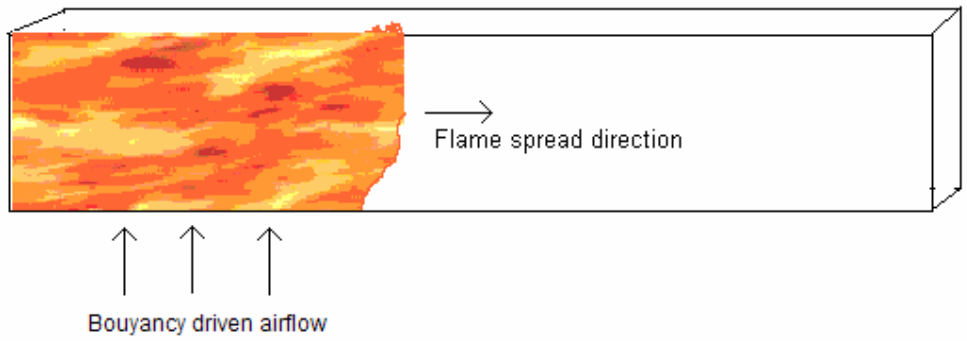



**Figure 1: Lateral flame spread**

Flame spread is often modelled as a series of piloted ignitions, so that as the area in adjacent to the flame front reaches the critical ignition temperature, then it ignites. This pyrolysis area is heated by gas phase conduction from the flame itself, as well as from the incident heat flux from any external heat source. Therefore, any study of flame spread will involve ignition and ignition theory to at least some degree.

Historically, the study of flame spread has resulted in empirical indices, which allow materials to be compared with each other, for that test procedure, but do not lead to material properties suitable for further calculation or modelling. Such tests involving lateral flame spread include BS478 Part 7 and ASTM E 162 (Surface flammability testing of materials using a radiant heat energy source) (Hilado, 1973). These give an index value, based on the extent of flame spread. The ASTM E 1321-97a LIFT test is

different in that it provides flame spread theory and the required material properties to allow modelling of flame spread.

## *2.1 Ignition*

The study of flame spread and the flame spread rate depends on the ignition properties of the material being tested. The study of ignition can be divided by the means of starting the ignition – either piloted or unpiloted (autoignition). Most of the study of ignition for fire engineering is piloted ignition, as this is more conservative, as the minimum heat flux required for piloted ignition and the resulting minimum surface temperature is less than the unpiloted equivalents. For laboratory testing, the pilot ignition source is generally a spark, hot wire or a gas flame, depending on the apparatus design. Flame spread is a piloted ignition process.

There are a number of models for predicting ignition under varying flux conditions, which are discussed in depth by Babrauskas (2003, 2001), and some of these models have been compared with experimental results by Ngu (2002).

The ASTM E 1321-97a LIFT standard is based on the work by Quintiere et al (1981, 1983, 1984) and hence uses the ignition theory developed there. Other theories on ignition have been developed since, which attempt to give more accurate predictions or address the assumptions and simplifications made by Quintiere et al.

At the simplest level, a material will ignite when a sufficient quantity of material has pyrolised to reach the lower flammable limit, and in the case of a piloted ignition, a suitable ignition source is available. Using the pyrolysis of the material as an ignition criterion is often not practical, particularly for design purposes. More desirable is a value for the incident heat flux or a temperature at which the item will not ignite, and hence the fire will no longer spread.

To achieve this objective, ignition theory can be divided into several areas, depending on the material properties and thickness. Much ignition theory is based on the concept of heat transfer to and from a quasi steady control volume. The final outcome is a function of the material thickness. At one extreme, a thin material can be effectively at constant temperature throughout and so the temperature from the rear face away from an incident heat flux is the same as the front. The resulting temperature rise, and

hence time to ignition, can be calculated from the material properties and heat transfer boundary conditions.

At the other extreme is a "thick" material, where there is no heat loss from the back of the sample. The development of the ignition theory Quintiere and Harkleroad (1983) which forms the basis of the LIFT test, given later in this report, is based on "thermally thick" heat transfer.

### 2.1.1 Definition of ignition results

There are some similar but confusing outcomes from ignition tests, regardless which ignition theory is used. A common requirement is to find the lowest heat flux level at which ignition will occur. Based on this, the likelihood of an item made from that material igniting as a result of the radiant heat flux can be calculated. This forms the basis of much of the legislation limiting heat flux from fires across property boundaries (Babrauskas, 2003)

There are 2 "lowest" heat flux from ignition test data - the minimum heat flux for ignition ($\dot{q}''_{ig,\min}$) and the critical heat flux ($\dot{q}''_{crit}$), and it is important not to confuse the terms.

*Minimum ignition flux*

The minimum heat flux for ignition is the lowest level at which the material will ignite within some time limit, and this varies depending on the requirements of the test protocol. It is found by a series of ignition tests, until the sample will no longer ignite within the allowed time limit, and so the plot of the time to ignition vs. the incident heat flux asymptotes to the minimum ignition flux. The value for $\dot{q}''_{ig,\min}$ is found by the average of the highest level where there is no ignition, and the lowest level that caused ignition within the allowable time, e.g. the ASTM E 1321-97a test standard calls for this value to be found by bracketing to within ±2kW/m$^2$.

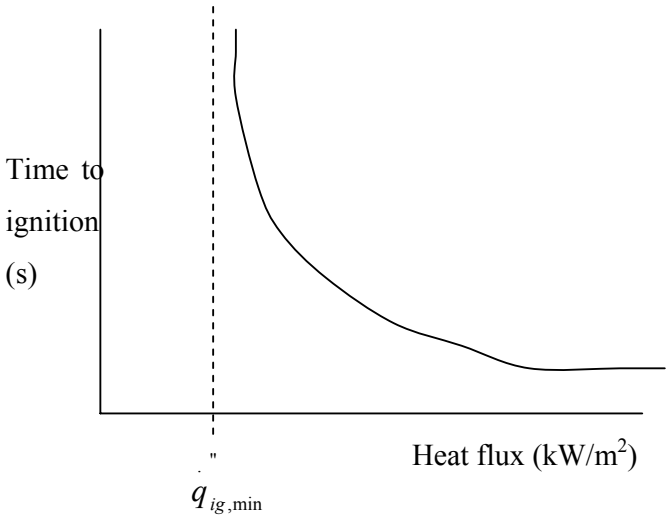



**Figure 2: Minimum ignition flux**

*Critical ignition flux*

Unlike the minimum ignition flux, the critical ignition flux is found by correlation, rather than as an experimental value, and different ignition theories can give different results. It is the theoretical lowest flux which will cause ignition, given an infinitely long time. Implicit is that the material properties do not change significantly during that time.

Quintiere's model assumed a thermally thick material, whereby there is no heat loss out of the material through the back of the sample, and the material behaves like an inert solid with no thermal decomposition or reaction. Plotting the ignition flux against (1/√(time to ignition)) and fitting a straight line to the data (

Figure 3) gives the critical heat flux at the intercept at the x- axis.

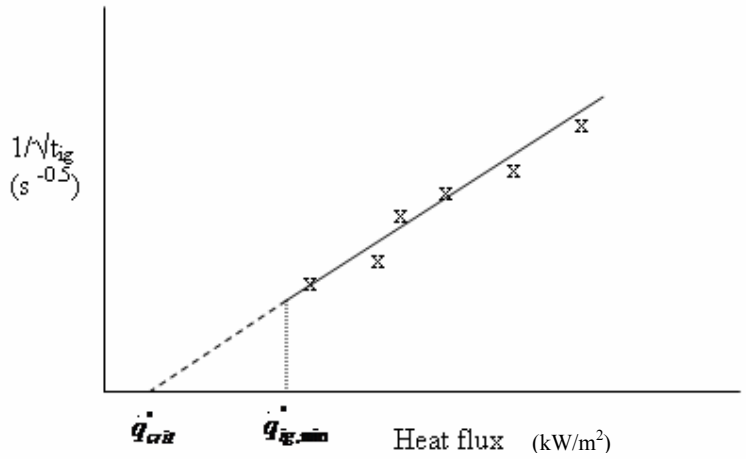



**Figure 3: Critical heat flux**

An alternative thermal ignition model which gives a value for the critical heat flux and is also widely used is that of Janssens (1991). It is similar to the Quintiere and Harkleroad model, except the basis for the derivation means that the data is plotted as (incident heat flux) $\dot{q}''_e$ vs. (time to ignition)$^{0.55}$, rather than (time to ignition)$^{0.5}$ as for Quintiere and Harkleroad. The value of the exponent for Janssens theory (0.55) applies if the material is thermally thick. The intercept with the x-axis gives $\dot{q}''_{crit}$ as above. As a result, the value for $\dot{q}''_{crit}$ is often slightly higher than that given by Quintiere and Harkleroad (1983) for the same data set. (Babrauskas, 2003).

*Thermal inertia $k\rho c$*

Thermal inertia is defined as the product of the specific heat of the material ($c$), the thermal conductivity ($k$) and the density ($\rho$).

It is a measure of how easily the material absorbs energy and hence how quickly the temperature will rise to ignition. A material with a low thermal inertia will ignite sooner than one with a high thermal inertia under the same conditions and ignition temperature, as more energy must be absorbed to raise the surface temperature by the same amount.

A summary of the theories and research into the ignition of wood is given by Babrauskas (2001, 2003). Seven different ignition theories, including the Quintiere and Harkleroad model used in the LIFT standard and that of Janssens, are compared experimentally by Ngu (2002).

### 2.1.2 Effect of sample orientation on ignition

. The ASTM E 1321 LIFT test uses an ignition test where the sample is held in the vertical plane, whereas the conventional cone calorimeter and ISO 5657 – 1986 test for ignition of samples subjected to thermal irradiance uses a sample in the horizontal orientation. The detail of each test apparatus is discussed later in this report. It is anticipated that the ignition tests for the RIFT will generally use the horizontal orientation in the ISO 5657 ignition testing apparatus or the cone calorimeter, although ignition tests were conducted in the RIFT in the vertical position, in order to compare the results.

Shields, Silcock and Murray (1993) did extensive work on the ISO 5657 ignition apparatus in various orientations, and compared the results to the cone calorimeter. The ISO 5657 apparatus used the "nodding" gas pilot flame applied at 4 second intervals (Babrauskas, 2003), rather than the spark ignition used in this report, and the time to ignition for the cone calorimeter and the ISO 5657 apparatus was similar, allowing for the margin of error due to the interval of the nodding gas pilot ignition system. Ignition times were similar for horizontal and vertical orientation, for heat fluxes between 50-70kW/$m^2$, but at lower flux levels (down to 20kW/$m^2$), there was significant difference with orientation, with vertical samples taking longer to ignite, and inverted samples several times longer still.

Babrauskas (2003) notes that the original version of the apparatus developed by the Experimental Building Station (now CSIRO) in Australia had provision for both the gas ignition system and an electric spark ignition system.

Dietenberger (1996) found that the time to ignition for samples in the cone calorimeter, with a horizontal sample, was less than that for the LIFT. This is shown in Figure 4, where the results for the ignition in the cone calorimeter are in the horizontal position, and the others are from the LIFT in the vertical position.

### 2.1.3 Effect of sample size

The size of the sample can have an effect on the time to ignition, particularly in the vertical orientation. The main difference as the sample height increases is the thickening of the boundary layer and hence the convection coefficient. The main source of heat loss from the sample face is convection, which is proportional to (the height of the sample $)^{1/4}$. (Babrauskas, 2003)

### 2.1.4 Effect of pilot ignition source

The pilot source and type is recognised as a source of error in ignition testing. The error can come from the pilot itself, or the manner in which it is applied, where a directly impinging pilot flame will cause ignition sooner than one which is remote from the sample. Similarly, if a gas flame is used, and the pilot flame is sufficiently large, the heat flux from the pilot flame can lead to a local heat flux which is higher than the nominal value. Similarly, if the pilot source is to far away from the sample, or poorly placed, the ignition time will increase, as the pyrolised material will be diluted with ambient air, decreasing the concentration of flammable gas.

In the original research that looked at the flame spread due to radiant panels, such as the LIFT apparatus, Quintiere (1981) used a "weak" pilot flame. This was formalised experimentally by Quintiere, Harkleroad and Walton (1983) to give the location in the ASTM E 1321 standard. This is mounted above the sample with a backing flange to provide a laminar flow of pyrolised material to the pilot flame.

The apparatus can have an additional effect. The original ISO 5657 ignitibility apparatus, as used by Shields, Silcock and Murray (1993) used a pilot gas flame, applied at 10 second intervals to the sample. This automatically introduces an error in the time to ignition, solely due to the resolution of the pilot flame application. The ISO 5657 apparatus used for this report uses a spark ignition, similar to the cone calorimeter, in order to reduce this systematic error.

Babrauskas (2003) reports several experiments comparing spark and gas ignition. Gas flame pilots are shown to give more inconsistent results than a spark ignition pilot, with generally shorter ignition times, due to local heating, even with "non impinging" pilot flames. Babrauskas recommend a spark ignition as the preferred pilot source.

### 2.1.5 Effect of moisture content on ignition

The moisture content of the samples, particularly wood, can have a large effect on the time to ignition. This will also then have an effect on the flame spread rate, since this is also affected by the ignition properties of the material. Dietenberger (1996) conducted experiments with the LIFT and cone calorimeter on redwood, with oven dried (0% MC), 30% and 50% moisture content. The resulting increase in the time to ignition for various moisture content levels is shown in Figure 4.

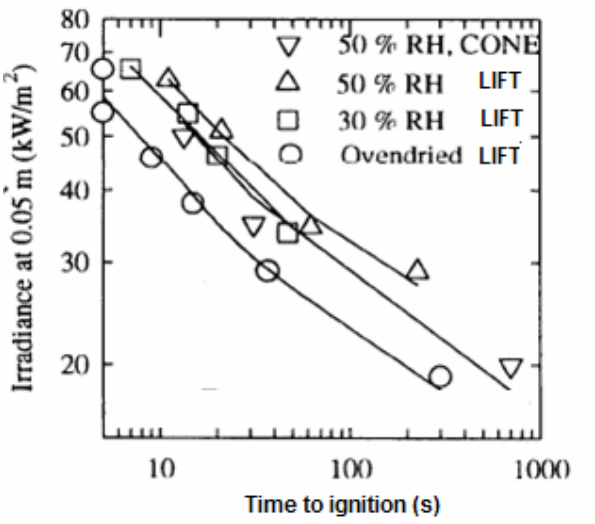



**Figure 4: Effect of moisture content on ignition time for redwood in LIFT and cone calorimeter. Adapted from Dietenberger (1996)**

The effect on moisture content on the ignition temperature (and hence the heat flux for ignition) can be seen in Figure 5 with the ignition temperature increasing with the moisture content.

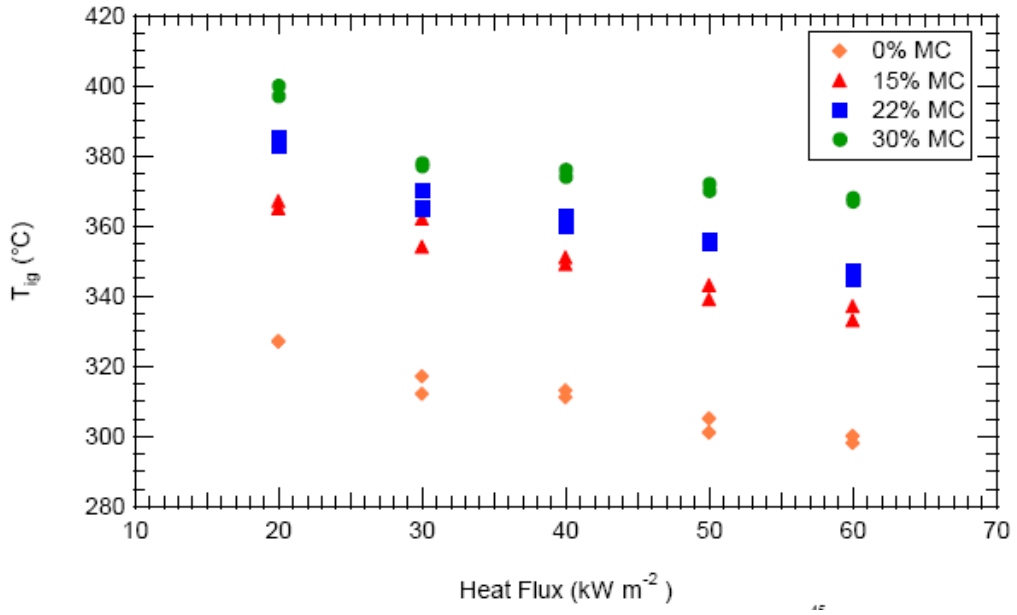



**Figure 5: Heat flux vs. ignition temperature for Radiata Pine. From Moghtaderi et. al (2005)**

Of greater importance to this report, Babrauskas notes that changes in moisture content of timber at room equilibrium do not make a significant difference to ignition

time (Babrauskas, 2001) and that differences in ignition times for timber moisture contents between 0-12% MC is lost in the data scatter.

### 2.1.6 Effect of Sample thickness

The thickness of the material affects the time to ignition as it affects the heat loss through the rear of the sample. At one extreme, the material is "thermally thin", so that the rear of the sample is effectively at the same temperature as the radiated face. The temperature of the sample then depends on the boundary conditions of both the front and rear face, for example if the face is insulated or under natural or forced air flow. At the other extreme, the material is "thermally thick", where the thickness of the material is such that there is no thermal penetration to the rear of the sample and hence no heat loss from the rear face. Some ignition theories for predicting the time to ignition, such as those used to develop the protocol for the ASTM LIFT test require that the material is thermally thick.

While materials over 1mm in thickness are generally thermally thick or thermally indeterminate, it depends on the flux level and preheating time. (Babrauskas, 2003). A lower flux level will give a longer time until the ignition temperature is reached, leading to greater thermal penetration. Hence, all materials behave as thermally thick for high heat fluxes with a correspondingly short ignition time, but increasingly behave as thermally thin at lower flux levels and longer ignition times.

The time for thermal penetration to depth D is given by Karlsson and Quintiere, (2000) as

$$t_p = \frac{D^2}{4\alpha} \qquad \textbf{(1)}$$

Where $\alpha$ is the thermal diffusivity.

$$\alpha = \frac{k}{\rho c} \qquad \textbf{(2)}$$

The problem with using Equation (1) to define the minimum thickness is that the properties used to calculate the thermal penetration depth and time are unknown and derived from the ignition test.

For wood products, Babrauskas (2003) summarises many of the findings into this area. For wood products, a rule-of-thumb for the thermal depth D is given by Equation (3) with a comment that several exceptions have been found.

$$\frac{D}{500} = \frac{0.6\rho}{q_e''} \qquad \textbf{(3)}$$

As the ignition and flame spread theory for the LIFT standard is based on materials being thermally thick, then the thickness of the materials should be chosen to be thermally thick. The ASTM E 1321-97a standard (section X.1.1.1) notes that materials in this category are typically 2-5mm thick, and where the material is less than this, the results apply to the facing and substrate combination as the substrate can have a significant effect on the ignition and flame spread results.

## *2.2 Theories of ignition*

A large number of ignition theories have been developed, in order to predict the likelihood and time to ignition of materials, with varying degrees of complexity. Two common ones which can give the material properties for use in the flame spread model are outlined in the following sections.

The problem of ignition can be treated as a heating problem, with a surface receiving radiation, and losing heat via radiation and convection from the surface (Figure 6), and solving as an energy balance. This also assumes that reactions within the material or on the surface are not significant. This may not always be true if, for example, the production of smoke or water vapour interferes with the received radiation, or alters the material properties.

For an inert solid, an approximate solution is possible for the heat transfer to and from the surface, given in equation (4) (Babrauskas, 2003):

$$T_{ig} - T_{\infty} = \frac{\dot{q}''_e}{h}\left[1 - \exp\left(\frac{h^2 \alpha t_{ig}}{k\rho c}\right) erfc\left(\sqrt{\frac{h^2 \alpha t_{ig}}{k\rho c}}\right)\right] \qquad \textbf{(4)}$$

Where $h$ is the effective linearised heat transfer coefficient, with both radiative and convection components and $\alpha$ is the surface absorptivity. The radiation losses are proportional to $T^4$ and hence a linearised heat transfer coefficient can only be accurate over a short range.

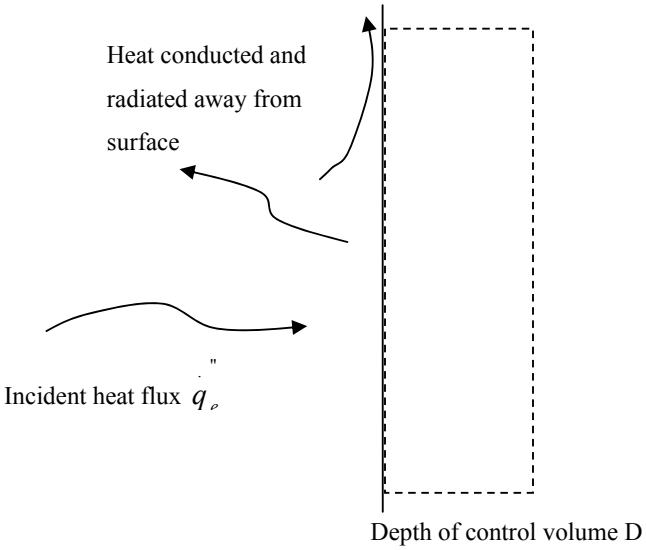



**Figure 6: Control volume for ignition**

Babrauskas (2003) notes that the application of Equation (4) is difficult, as there are practical difficulties in experimentally calculating the values. It is mathematically complex, and the Gaussian error function complement (erfc) is prone to rounding error when multiplied with the exponent value.

The ignition temperature at ignition is difficult to measure and there is a wide variation in values. Babrauskas (2001) lists a summary of values obtained by various methods, and these range from 228°C to 420°C. The value observed are dependent on the apparatus, orientation, flux level and measurement method (Fangrat et al, 1997). Generally the heat flux is known or more easily measured than the surface temperature at ignition, so any solution should not rely on the ignition temperature for the final result.

### 2.2.1 Quintiere, Harkleroad and Walton (1983) and Quintiere and Harkleroad (1984)

The ignition theory developed by Quintiere, Harkleroad and Walton (1983) and further developed by Quintiere and Harkleroad (1984) forms the basis for the ignition tests in the ASTM E 1321 LIFT ignition tests, and the basis for the material properties

used in the flame spread part of the test. It is based on an energy balance into a control volume for an infinite 1 dimensional slab (Figure 6).

Some assumptions are made:

- The material under test is modelled as an inert, grey body.
- The temperature in the control volume increases under the received heat flux until it reaches the ignition temperature ($T_{ig}$)., at which point it ignites
- More generally, the sample is assumed to be "well behaved" with homogeneous properties, unaffected by the temperature increase to ignition, and the surface does not melt or blister.

The material is assumed to ignite once the surface temperature ($T_{surf}$) reaches the minimum temperature for piloted ignition ($T_{ig}$), and this temperature increase is due to the increase from the external flux and the flame heat flux, i.e.:

$$T_{ig} - T_{surf} = \Delta T_e + \Delta T_f \quad \textbf{(5)}$$

Taking an energy balance on the control volume, the minimum heat flux to raise the temperature of the surface to the ignition temperature is:

$$\dot{q}''_{ig,\min} = h_c (T_{surf} - T_\infty) + \varepsilon\sigma (T_{surf}^4 - T_\infty^4) \cong h(T_{ig} - T_\infty) \quad \textbf{(6)}$$

Where h = linearised heat transfer coefficient, including the radiation component, and the emissivity ε = 1, as the surface chars before ignition.

The surface temperature required for ignition can be calculated from Equation (6) if a heat transfer coefficient $h$ is known. Experiments by Quintiere, Harkleroad and Walton (1983) showed the heat transfer coefficient was relatively constant across the temperature range of materials commonly tested in the LIFT at 15 kW/m$^2$K. Further work by Dietenberger (1995) showed that in fact the heat transfer coefficient varied along the sample, and that 15 kW/m$^2$K was a simplification. As the surface temperature of the sample varies with position, due to the varying heat flux levels, the heat transfer coefficient will also vary as well. This is further complicated by the effect of the gas fired radiant panel in the LIFT, which provides a turbulent flow due to burning gas from the panel (Babrauskas, 2003).

Treating the control volume as a semi infinite, thermally thick solid with one dimensional heat flow into the solid gives the Newtonian heating equation in Equation (4), rewritten by Quintiere et al (1983) as Equation (7) - Equation (9) for the surface temperature at ignition, where the absorptivity $\alpha$ in Equation (4) is assumed to be equal to 1.

$$\Delta T_e = T_{ig} - T_\infty = \dot{q}''_{e,x_f} \; [1 - \exp(at) erfc\sqrt{at}\,] / h \qquad \textbf{(7)}$$

$$a = \frac{h^2}{k\rho c}$$

or

$$\Delta T_e = T_{ig} - T_\infty = \dot{q}''_{e,x_f} \; F(t) / h \qquad \textbf{(8)}$$

Where *F(t)* is the time transient term

$$F(t) = 1 - \exp(at) erfc\sqrt{(at)} \qquad \textbf{(9)}$$

As the time the sample is exposed to the external flux increases, then the time transient term *F(t)* tends to zero as the material surface approaches equilibrium.
From ignition tests (Cleary, 1992) the time transient *F(t)* is related to the flux levels:

$$\frac{\dot{q}''_{ig.\min}}{\dot{q}''_e} = F(t) = \begin{cases} b\sqrt{t} & t \le t^* \\ 1 & t \ge t^* \end{cases} \qquad \textbf{(10)}$$

The thermal equilibrium time $t^*$ is calculated from the ignition data, where a plot of the ratio of the (minimum heat flux for ignition $\dot{q}''_{ig.\min}$ / incident heat flux $\dot{q}''_e$) versus (time to ignition)$^{0.5}$ (Figure 7).

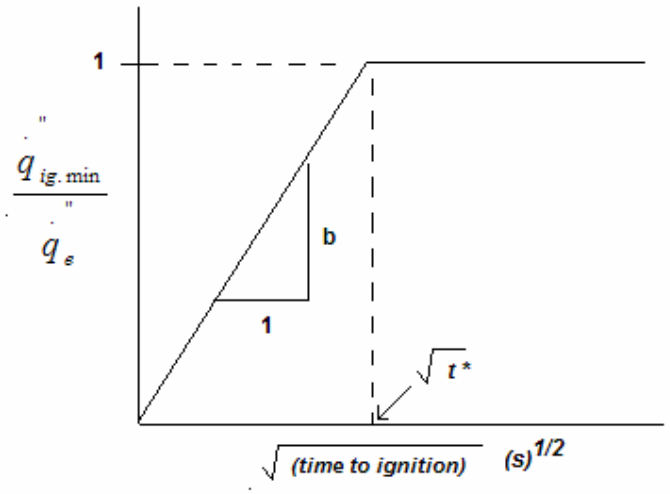



**Figure 7: Ignition data plot to find preheating time $t^*$ (from Cleary, 1992)**

As the time *t* increases then $F(t)$ tends to a value of 1 at long ignition times, shown in Equation (11), hence the plateau in Figure 7.

$$F(t) = 1 - \exp(at)erfc\sqrt{(at)} \rightarrow 1 \text{ as } t \rightarrow \infty \quad \textbf{(11)}$$

As the time t tends to 0 – i.e. at high heat fluxes with a correspondingly short ignition time, then the exponential term tends to a value of 1 and as a result *F(t)* tends to a function dependent on the thermal inertia, shown in Equation (12).

$$F(t) = 1 - \exp(at)erfc\sqrt{(at)} \rightarrow \frac{2h\sqrt{t}}{\sqrt{\pi k\rho c}} \text{ as } t \rightarrow 0 \quad \textbf{(12)}$$

Hence for the period of time when *t* is small, then the *F(t)* can also be written as

$$F(t) = \frac{2h}{\sqrt{\pi k\rho c}}\sqrt{t} \quad \text{as } t \rightarrow 0 \text{ or} \quad \textbf{(13)}$$

$$F(t) = b\sqrt{t}$$

Where b is the ignition parameter, given in Equation (14) and this can be used to derive the effective thermal inertia $k\rho c$.

$$b = \frac{2h}{\sqrt{\pi k\rho c}} \text{ or } k\rho c = \frac{4}{\pi}\left(\frac{h}{b}\right)^2 \quad \textbf{(14)}$$

### 2.2.2 Janssens

Although the theory by Quintiere et al is specified for the ASTM E 1321 LIFT standard, some researchers have used the ignition theory by Janssens to derive the required physical properties, a summary of which by Babrauskas (2003) is as follows. The basis is derived from Equation (4) however the absorptivity α is not necessarily equal to 1, which is assumed in the work by Quintiere.

Janssens showed that an approximation for the *F(t)* term in Equation (9) is

$$F(t) = 1 - \exp(at)erfc\sqrt{(at)} \approx \frac{1}{1 + 0.73(at)^{-0.55}} \qquad \textbf{(15)}$$

$$a = \frac{h^2}{k\rho c}$$

As the ignition time increases, so that $t_{ig} \rightarrow \propto$ at the critical ignition flux $\dot{q}''_{crit}$ then Equation (15 $\rightarrow$1.0, so then Equation (7) becomes Equation (16) at $\dot{q}''_{crit}$.

$$T_{ig} \approx T_{\infty} + \frac{\alpha \dot{q}''_{crit}}{h} \qquad \textbf{(16)}$$

And hence the effective heat transfer coefficient can be calculated

$$h = \frac{\alpha . \dot{q}''_{crit}}{\left(T_{ig} - T_{\infty}\right)} \qquad \textbf{(17)}$$

Rearranging Equation (8) gives Equation (18) for the energy balance on the surface due to radiant ignition.

$$h\left(T_{ig} - T_{\infty}\right) = \alpha . \dot{q}''_{e} . F(t) \qquad \textbf{(18)}$$

Equation (15) and Equation (17) are substituted into Equation (18) and the common terms, cancel out and Equation (19) gives the time to ignition at a certain heat flux.

$$\dot{q}''_{e} = \dot{q}''_{crit}\left[1 + 0.73\left(\frac{k\rho c}{h^2 t_{ig}}\right)^{0.55}\right] \qquad \textbf{(19)}$$

As a result of Equation (19), the material properties can be found with the following procedure.

Using the time to ignition data for various heat fluxes, as per the Quintiere method, plot $t_{ig}^{-0.55}$ on the y-axis against $\dot{q}''_e$ on the x-axis and fit a straight line to the data points. The value for the critical ignition flux $\dot{q}''_{crit}$ is the intercept with the x-axis.

The ignition temperature $T_{ig}$ is found iteratively from the energy balance at the surface at the minimum ignition flux using Equation (20).

$$\frac{\dot{q}''_{\text{min}}}{(T_{ig} - T_\infty)} = \frac{h_c}{\alpha} + \frac{\sigma(T_{ig}^4 - T_\infty^4}{(T_{ig} - T_\infty)} \qquad \textbf{(20)}$$

The value for the absorptivity $\alpha$ is specified as $\alpha = 1$ in the ASTM LIFT standard. More realistically, wood products are around 0.88, and typical plastics range from 0.64 to 0.92 (Babrauskas, 2003).

Given the ignition temperature and absorptivity, then the heat transfer coefficient can be found using Equation (16), and the effective thermal inertia $k\rho c$ can be calculated from Equation (21).

$$k\rho c = h^2 \left[ \frac{B_{ig}}{0.73 \dot{q}''_{\text{min}}} \right]^{1.828} \qquad \textbf{(21)}$$

where $B_{ig}$ = 1/(slope of data fit line)

## *2.3 Opposed flow (lateral) flame spread*

### 2.3.1 Principles of opposed flow flame spread

Work by Quintiere (1981), Quintiere, Harkleroad and Walton (1983) and Quintiere and Harkleroad (1984) led to the ASTM E 1321 LIFT test for lateral flame spread along thick materials burning in still air (i.e., with natural convection rather than forced flow), where flame spread has been modelled as a series of piloted ignitions. The material ignites when the preheated area reaches the ignition temperature ($T_{ig}$), and the ignition temperature is assumed to be constant over the temperature range (Quintiere, 2002). The preheating is from the radiation of the flame of already-burning material, any external heat flux and conduction through the material (Delichatsios, 1999), as shown in Figure 8. The heating from the flame is much less than for vertical or wind assisted flame spread, as the flame does not extend over the preheating area, hence there is reduced radiation from the flame to the unpyrolised surface. The main form of heat transfer into the unpyrolised surface is through the gas phase conduction from the flame front (Quintiere, 2002).

The heat loss from the area in front of the flame front which has not yet ignited leads to the requirement for a minimum heat flux impinging on the surface and resulting surface temperature for the flame to spread. Without the heat flux to raise the temperature of the material, either from the flame or from an external source, the surface temperature will not be high enough to reach the ignition temperature, and hence there is a limiting flux for the material to give the ignition temperature required for flame spread. This is given in the LIFT/ RIFT test as the heat flux at the point where the flame front ceases to advance. The analysis by Quintiere (1981) involved a moving control volume, shown in Figure 8.

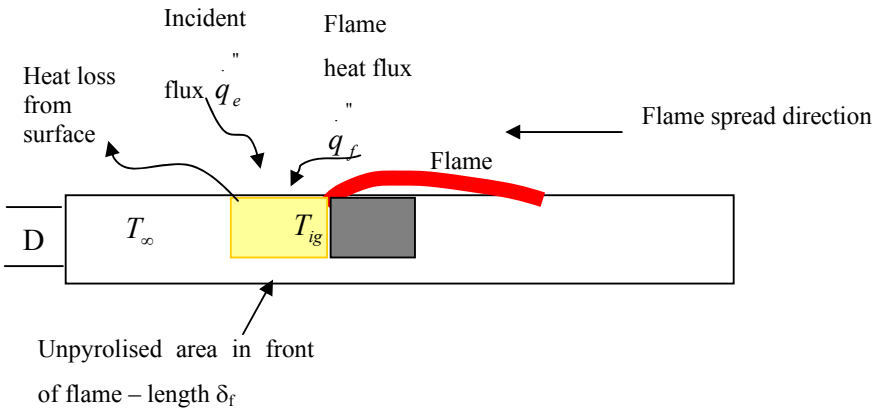



**Figure 8: Opposed flow flame spread**

The thickness of the material and any backing substrate can have some effect on the rate of flame spread and behaviour (Quintiere 2002). The ASTM E 1321 LIFT test requires the material to be thermally thick, whereby a thermally thick material does not have significant heat loss through the rear or sides of the sample, so that there is no significant temperature rise on the back of the sample.

For thermally thick materials, the flame spread velocity $V_f$ at any point along the sample (Equation (28) ) involves an energy balance into the control volume shown ahead of the flame front in Figure 8 (Quintiere et al, 1981) and the energy balance of the control volume can be used to give the material properties, as follows, from Quintiere et al (1983).

The solution depends on a number of simplifying assumptions:

- A key assumption is that the length of the control volume is small. This is valid for opposed flow flame spread, as the flame does not extend over the unpyrolised area, so the preheated are is limited by conduction from the flame. The length of the control volume is up to 2mm (Quintiere, 1981). The relatively short length of the control volume ($\delta_f$ in Figure 8) allows the assumption that the incident flux $\dot{q}''_e$ on the sample is constant over that length, allowing energy absorbed to be calculated and a simple energy balance to be used.

- The temperature in the control volume increases under the received heat flux until it reaches the ignition temperature ($T_{ig}$), at which point it ignites. The flame spread is therefore a series of ignitions along the sample – the flame front is at the position where the surface temperature is greater than or equal to the ignition temperature.
- The external radiation $\dot{q}_e''$ varies along the sample, however the radiation from the flame front $\dot{q}_f''$ is constant and independent of the external radiation.
- More generally, the sample is assumed to be "well behaved" with homogeneous properties, unaffected by the temperature increase to ignition, and the surface does not melt or blister.

The material is assumed to ignite once the surface temperature reaches the minimum temperature for piloted ignition ($T_{ig}$), and this temperature increase is due to the increase from the external flux and the flame heat flux:

$$T_{ig} - T_\infty = \Delta T_e + \Delta T_f \quad \textbf{(22)}$$

The depth of the control volume into the material ($D$ in Figure 8) is equal to the thermal penetration, which is material dependent, and is given in Equation (23) for an exposure of $t$ seconds. The depth of the control volume is "thin" over the time it takes to heat the length of the control volume from the ambient temperature to the ignition temperature, so the temperature of the control volume is assumed to be the same at any point at a given time.

$$D_t = \sqrt{\frac{kt}{\rho c}} \quad \textbf{(23)}$$

If the surface material is at equilibrium with the external heat flux $q_e''$ due to a preheating period, then an energy balance on a single unit control volume $D.\delta_f$ in size, moving at the flame front velocity $V_f$ is

$$\rho c D V_f (T_{ig} - T_\infty) \cong \dot{q}_f'' \, \delta_f \quad \textbf{(24)}$$

Taking an energy balance on the control volume, the critical heat flux to raise the temperature of the surface to the ignition temperature in an "infinite" time is given in Equation (6), reproduced below in Equation (25).

$$\dot{q}''_{e,crit} = h_c(T_{ig} - T_\infty) + \sigma(T_{ig}^4 - T_\infty^4) \cong h(T_{ig} - T_\infty) \quad \textbf{(25)}$$

Where h = linearised heat transfer coefficient, including the radiation component, and the emissivity ε =1, as the surface chars before ignition. Treating the control volume as a semi infinite, thermally thick solid with one dimensional heat flow into the solid gives the Newtonian heating equation in Equation (7), reproduced below in Equation (26) for the surface temperature up until ignition.

$$\Delta T_e = T_{surf} - T_\infty = \dot{q}''_{e,x_f}[1 - \exp(at)erfc\sqrt{at}]/h \quad \textbf{(26)}$$

$$a = h^2/k\rho c$$

$$T_{surf} = T_{ig} \text{ at ignition}$$

The surface ignites once it reaches the minimum surface temperature for ignition $T_{ig}$

The inverse square root of the flame front velocity is found to be proportional to the difference between the critical ignition flux and the incident flux at that point, as shown in Equation (28). Rearranging Equation (24) and Equation (26) and substituting into Equation (22) gives Equation (27)

$$T_{ig} - T_\infty = \left[\frac{\dot{q}''_f\sqrt{\delta_f}}{\sqrt{k\rho c}}\right] V_f^{-1/2} + \dot{q}''_{e,x_f}[1 - \exp(at)erfc\sqrt{(at)}]/h \quad \textbf{(27)}$$

or the flame front velocity is given as:

$$V_f^{-1/2} = C[h(T_{ig} - T_i) - \dot{q}''_{e,x_f}.F(t)] \quad \textbf{(28)}$$

where

$$C = 1/\dot{q}''_f\sqrt{a\delta_f} \quad \textbf{(29)}$$

$$F(t) = 1 - \exp(at) erfc\sqrt{(at)} \quad \textbf{(30)}$$

$$a = \frac{h^2}{k\rho c}$$

where $C$ = a material specific constant referred to as the flame heat transfer modulus.

The solution to Equation (28) requires the accurate measurement of the preheating area in front of the flame front as it progresses along the sample. This is practically difficult, given the objective is to find the properties of the material to solve Equation (23).

As the time the sample is exposed to the external flux increases, then the time transient term *F(t)* tends to zero as the material surface approaches equilibrium. For this reason, the sample in the LIFT flame spread test is preheated to equilibrium before ignition to simplify Equation (28)

The ignition parameter *b*, calculated from the ignition tests and equation (14), can be used to calculate the required preheating time $t^*$ to bring the material to thermal equilibrium, which is given by Equation (31) or from reading from the ignition parameter graph (Figure 7)

$$t^* = \left(\frac{1}{b}\right)^2 \quad \textbf{(31)}$$

As the heat flux along the sample is known, the minimum heat flux required for the flame to spread ($q_s^{"}$) is given by the location of the flame front when it self-extinguishes. Similarly, the minimum temperature for flame spread can be calculated from Equation (25), by setting the critical heat flux value in Equation (32) to that of the minimum flux for spread, and then solving for the temperature.

$$\dot{q}_s^{"} = h_c(T_s - T_\infty) + \sigma(T_s^4 - T_\infty^4) \cong h(T_s - T_\infty) \quad \textbf{(32)}$$

From Equation (27) and Equation (28), the flame velocity can be calculated. However it is difficult to do in practice as the length of the pyrolysis area $\delta_f$ is unknown. However, if the pyrolysis area is assumed to be constant for a given material due to the fact there is no flame impingement on the unpyrolysed area, and the other constants are included in a new value, then equation for flame spread velocity is as below:

$$V_f = \frac{\phi}{k\rho c(T_{ig} - T_\infty)^2} \quad \textbf{(33)}$$

Where the flame spread parameter $\phi$ can be derived from the experimental results using Equation (34).

$$\phi = \frac{\frac{4}{\pi}}{(Cb)^2} \quad \textbf{(34)}$$

# 3 The ASTM E1321-97a Lateral ignition and flame transport (LIFT) test apparatus

## *3.1 History*

The ASTM E 1321 standards series originated from the ASTM E 1317 Standard for marine surface finishes and work by Quintiere (1981) and Quintiere and Harkleroad (1982, 1984) and uses the same testing apparatus with the addition of a mathematical model of flame spread developed by Quintiere (1981). The difference between the two standards is principally with the pilot flame location and the addition of a 180mm long flange behind the pilot flame at the top of the sample holder. The ASTM E 1317 standard uses a vertical pilot flame at the hot end of the sample, approximately 10mm away from the sample. The ASTM E 1321-97a standard calls for a horizontal pilot flame, above the top edge of the sample with a vertical backing flange, so that the radiation from the burner flame does not affect the time to ignition results by increasing the heat flux received by the sample.

The ASTM E 1317 standard also uses a thermopile in the hood to give basic heat release data, and this is not used in the ASTM E1321-97a test.

## *3.2 Requirements of the ASTM E 1321-97a LIFT apparatus*

The standard LIFT testing apparatus uses a gas fuelled diffusion burner and a vertical sample holder, angled at 15 degrees away from each other (Figure 9). The plans for the ASTM E 1317, upon which the ASTM E 1321-97a LIFT test is based, were issued by the National Bureau of Standards and are available from the ASTM as ADJE1317 Adjunct to ASTM1321-97a.

The 155 x 800mm sample holder is angled at 15°± 0.25° to the face of the burner (Figure 9). The hot end of the sample is 125mm away from the face of the burner, and offset from the edge of the burner by approximately 125mm (Figure 10). The burner is a flat panel burner 280mm high x 430mm long, with radiant ceramic elements and a reverberant screen. This is mounted so that it allows the burner

assembly to rotate to allow horizontal testing, although this is outside the standard test procedure. The rotating ring assembly can be seen behind the burner in Figure 11.

The burner offset can be adjusted to give the best match to the standard flux profile (Figure 12). This gives an almost constant flux level for the first 150mm along the sample for use in ignition testing, and then a decreasing flux level to approximately 2% of the peak heat flux.

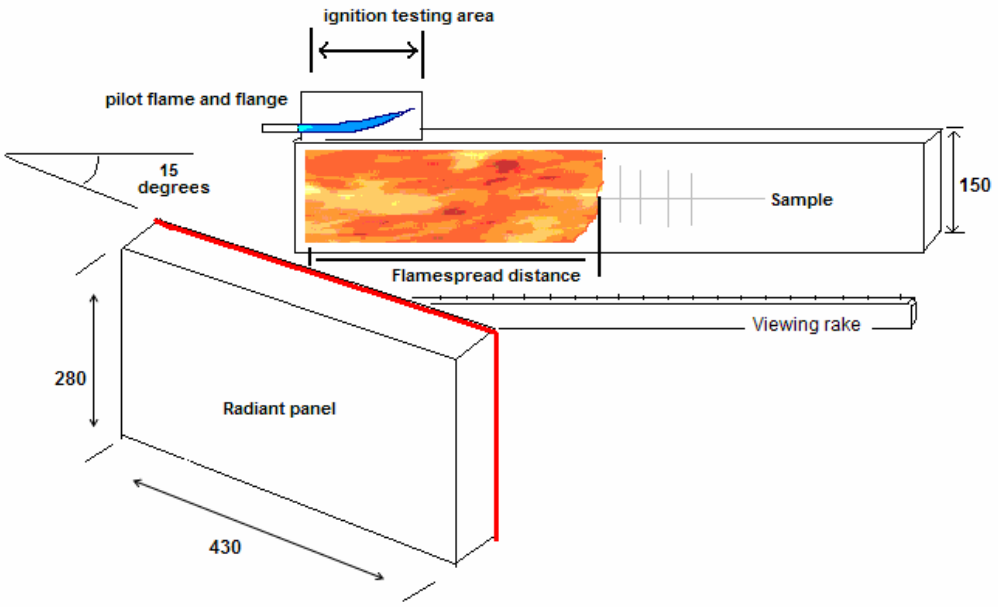



**Figure 9: Main components of LIFT apparatus**

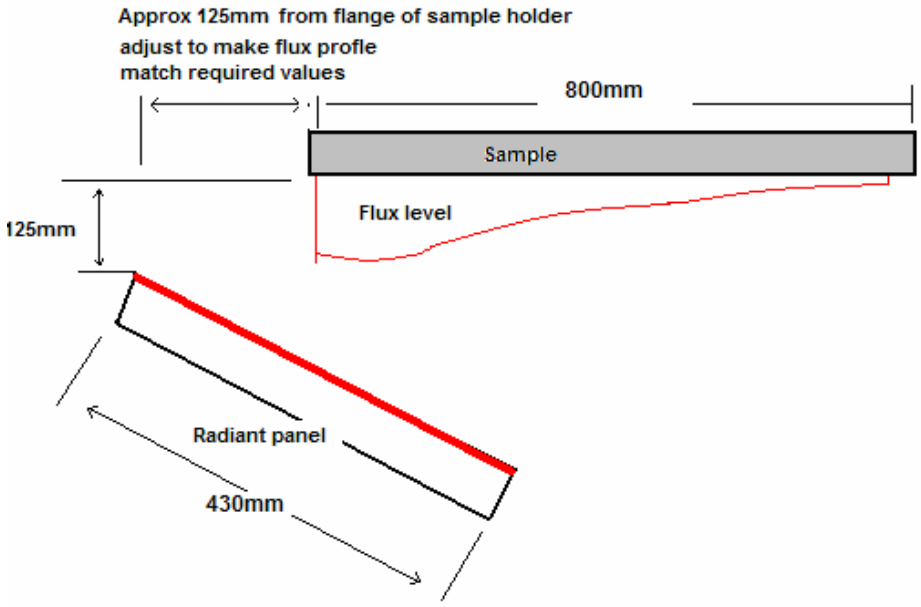



**Figure 10: Schematic of LIFT apparatus**

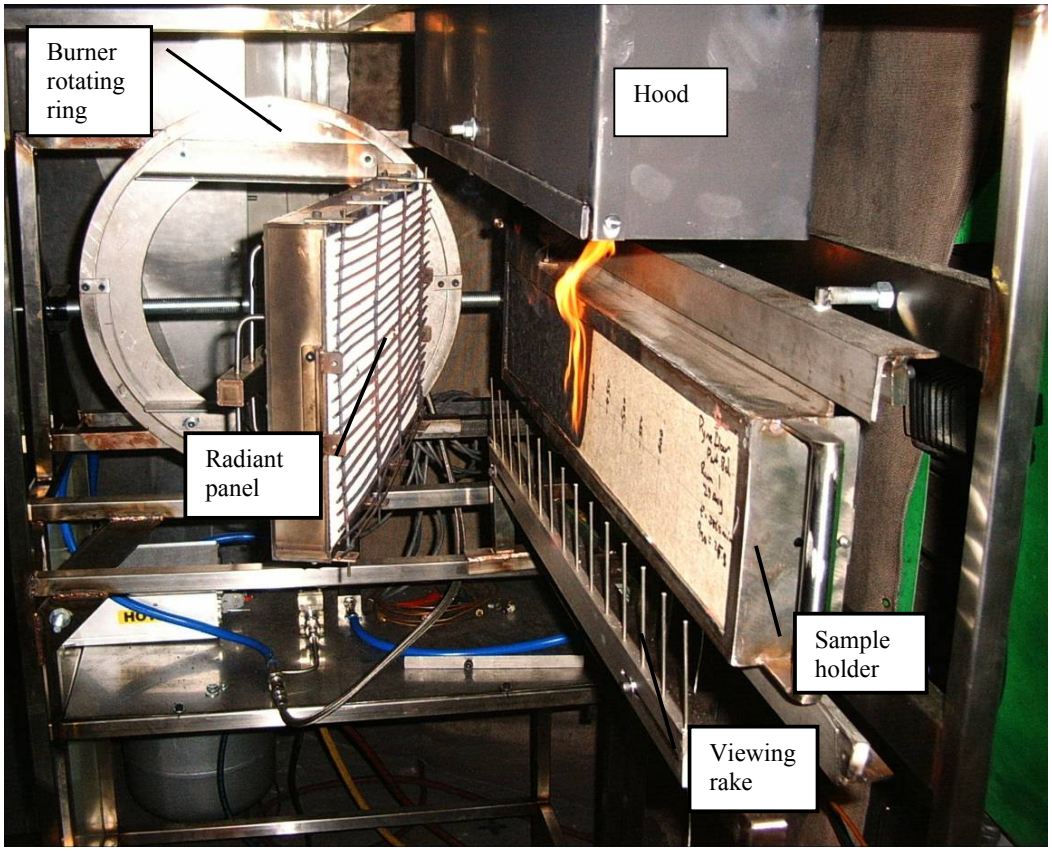



**Figure 11: LIFT showing angled gas radiant panel (left) and sample holder (right)**

The results from the ignition or flame spread tests can be observed directly or via on observation mirror, which is at the front of the unit and angled to look under the

burner, and this can be seen more clearly in Figure 13. A viewing rake, seen under the sample holder in Figure 11, allows the operator to monitor the flame spread along the face of the sample.

The output of the burner can be varied to suit the desired flux levels by altering the air and gas settings. The standard calibration output, measured at the sample face, is shown in Figure 12.

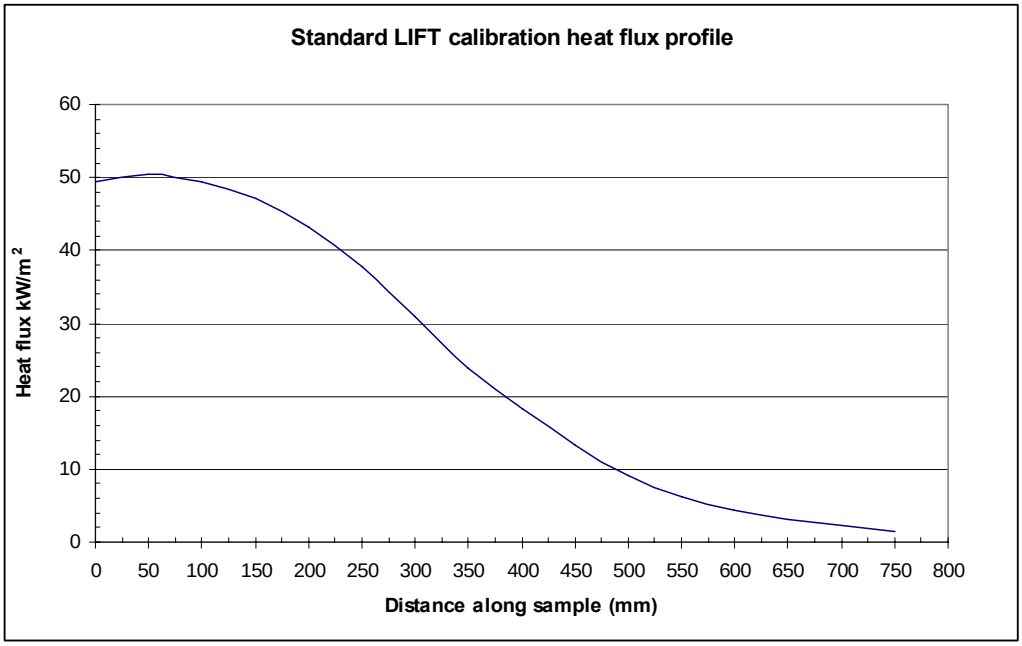



**Figure 12: Standard ASTM E 1321 LIFT heat flux distribution for calibration**

## *3.3 The University of Canterbury LIFT apparatus*

### 3.3.1 Apparatus description

The LIFT apparatus used in these experiments was built in the University of Canterbury (UC) over a period of 5 months in 2005. While it follows the design for the ASTM E 1317 apparatus (Adjunct to ASTM E 1317), with the modifications listed for the ASTM E 1321-97a standard, there are some variations. The main variation from the ASTM standard is the fuel used for the burners. The ASTM E 1321-97a LIFT standard calls for methane powered main burner with an air-acetylene pilot flame, whereas the University of Canterbury LIFT uses Liquefied Petroleum Gas (LPG) – a mixture of propane and butane - for both burners, controlled via mass flow

controllers and a variable pressure air regulator (Figure 13). The radiant panel also has adjustable spacing using a leadscrew and hand wheel (Figure 14) to allow for lower heat fluxes for the ignition tests than the LPG fuelled burner can provide.

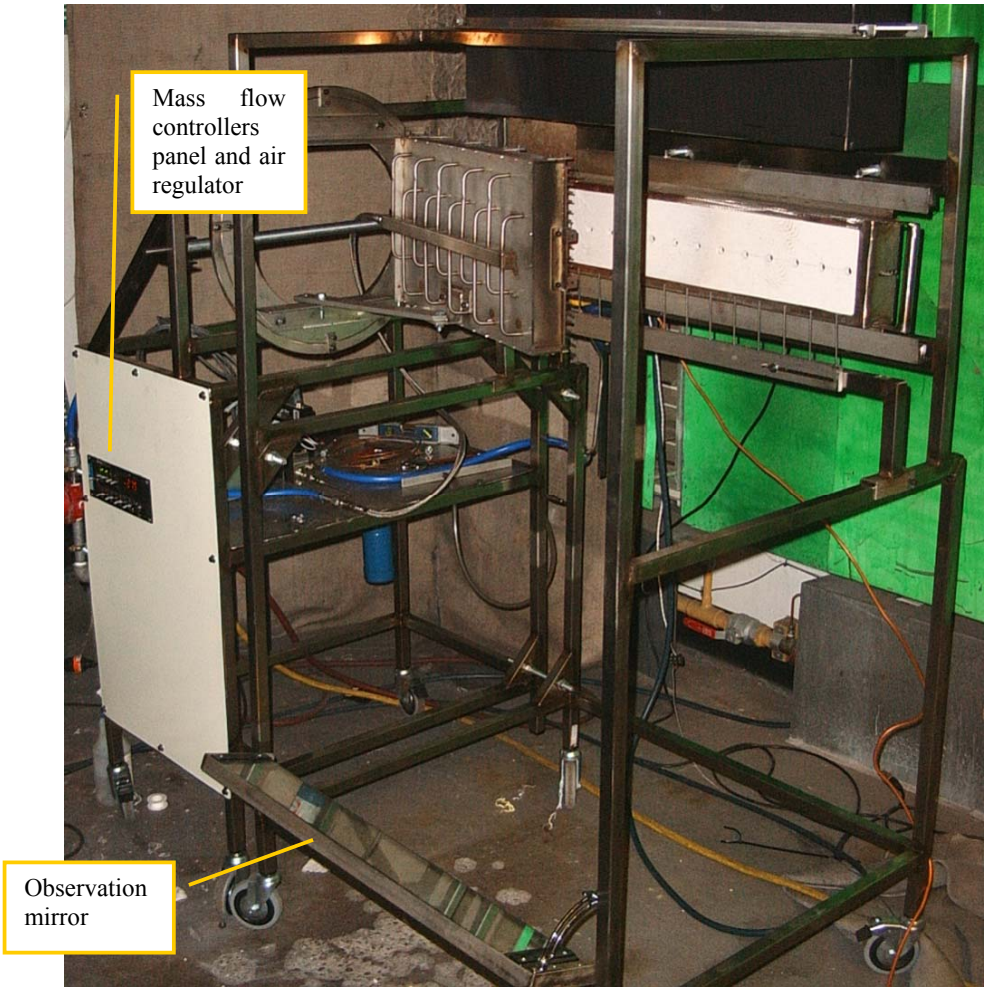



**Figure 13: University of Canterbury LIFT apparatus with measuring template in sample holder**

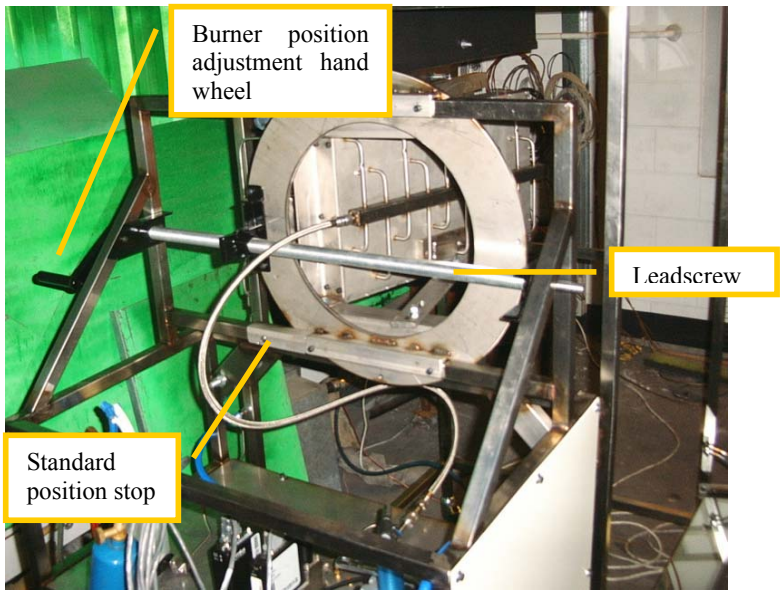



**Figure 14: UC LIFT burner position adjustment showing rails and leadscrew**

### 3.3.2 Fuel and air supply

Due to the unavailability of methane, the UC LIFT uses LPG and a compressed air supply for the main radiant panel burner fuel and the pilot flame. The decision to use methane for the burner used in the original research (Quintiere, 1981) and the subsequent ASTM standard was dictated by the wider range of the methane fuelled radiant panel for the ignition test which form part of the experimental procedure. The spacing of the propane fuelled radiant panel used in this case can be adjusted, as the burner can slide on rails and the position is set by using a lead screw (Figure 14) to give the lower flux levels within the limitations of the burner output. This is only for the ignition tests, as the radiant panel can be used with the standard spacing for the flame spread tests.

The use of LPG fuel for the burner is justified by the previously published work in the literature. LPG is a mixture of propane and butane, and propane has been used for ignition experiments with the ASTM E1623 ICAL intermediate scale calorimeter (Grand and Mehrafza 2001), which also normally runs on methane or natural gas. The ICAL procedure also uses a fixed sample, and changes the distance from the burner to alter the flux received by the sample. Similarly, in a round robin test of the IMO Resolution A. 653 (16) marine finishes flame spread test (also known as the ASTM E

1317 standard) which uses the same apparatus as the ASTM E 1321 LIFT test, it was noted that one of the laboratories used propane for the radiant panel burner, although this was later changed to methane. (Pauner, 2003).

The propane powered radiant panel burner used in the UC LIFT has a lower limit of $\dot{q}''_{50mm}$ = 25kW/m$^2$ at the 50mm measuring point when set up in accordance to the standard LIFT spacing (Figure 10), as the burner behaviour becomes unstable and has uneven heating below this level. From the observed conditions during the experiments, it appears that a change to the gas manifold to allow a more even entry of gas to the centre of the gas panel would allow a setting lower than the 25kW/m$^2$ limit currently imposed, by reducing or eliminating the uneven burning across the face of the panel, giving a lower limit of approximately 20kW/m$^2$ on LPG.

The limitation of $\dot{q}''_{50mm}$ = 20-25kW/m$^2$ for the propane fired panel of the UC LIFT is not generally a limitation for the flame spread tests, as the flux level is usually set to 5-10kW/m$^2$ over the minimum ignition flux, and for timber based products, the minimum ignition flux is usually in the order of 12kW/m$^2$ (Babrauskas, 2001), and usually higher for ignition tests conducted in the LIFT (Babrauskas, 2003). The level that the panel is set at is not critical, as it is only to increase the resolution by reducing the step size between each measuring point, and to reduce charring during the preheat period.

An upper limit was found of $\dot{q}''_{50mm}$ = 50 kW/m$^2$ , due to the air supply to the burner. The air compressor used was unable to supply sufficient air for the burner at higher outputs. In trials using an additional air compressor in parallel with the main air supply, the burner was capable of producing heat fluxes greater than $\dot{q}''_{50mm}$ = 60kW/m$^2$, but there was not sufficient air capacity to hold this level for extended periods.

At heat flux settings less than $\dot{q}''_{50mm}$ =30kW/m$^2$, initial tests showed erratic output form the burner, where it cycled in a periodic manner, shown in Figure 15. The

problem was traced to a combination of the air compressor cycling and variation of the output of the air supply regulator. Changing the air compressor set points to increase the running time, and adding a ball valve to allow some preload of the regulator to a minimum of 8psi gauge pressure significantly reduced this problem. It can be seen in Figure 16 that the heat flux output with the regulator preloaded to 8psi is more stable than without any preload.

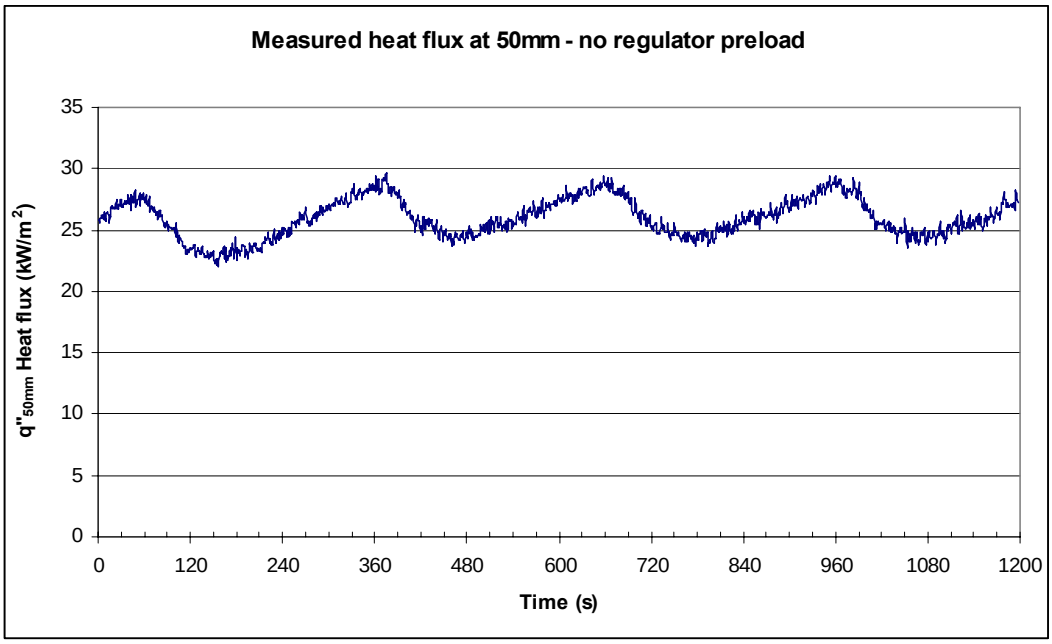



**Figure 15: Heat flux variation without preloaded air regulator**

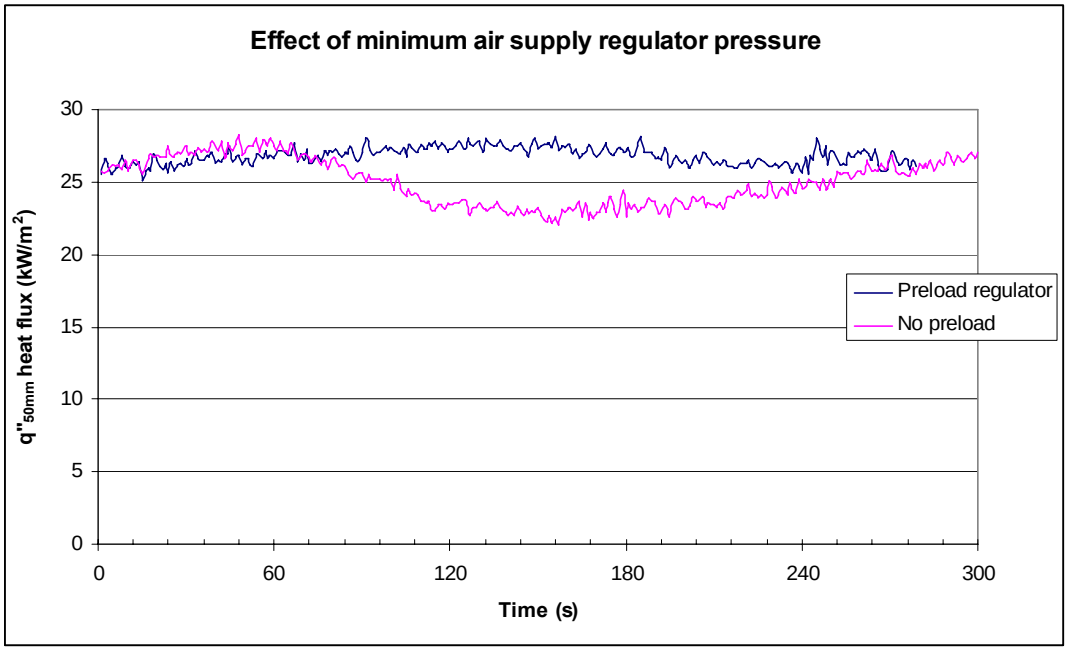



**Figure 16: Effect of preloading air regulator to minimum of 8psi on heat flux variation**

### 3.3.3 Flux measurement and calibration

Both the LIFT and the RIFT require a measurement of the heat flux at points along the sample face, to allow the calculation of the flame spread velocity and minimum flux level for flame spread. This is done by using a water cooled flux gauge with a template. The template is made from rigid refractory board, with holes drilled at intervals to suit the head of the flux gauge. The head of the flux gauge is to be a snug fit in the holes, without excess clearance; 12.7mm (1/2 inch) diameter holes were used in the templates. The hole spacing for the LIFT template is at 50mm centres, measured from the edge of the flange of the sample holder.

The heat flux gauge was bent to allow it to be clamped to the rail behind the sample holder (Figure 17), in order to keep the flux gauge in place and at a consistent angle while measurements were taken. In use, it was found that care had to be exercised to ensure that the head of the heat flux gauge was flush with the face of the template and not shielded by being inside the hole. Other work, outlined in Section 10.1, indicates that having the head of the flux meter proud of the surface of the template,

particularly at the cold end of the sample, will improve the accuracy of the measurements.


**Figure 17: Flux gauge and template**

For the initial calibration for the radiant panel position, the panel was set to the standard angle and position (Figure 10). With the burner output to 50kW/m$^2$, measured at the 50mm position, the flux levels were measured at 50mm intervals along the sample template using a calibrated heat flux meter. When compared to the standard values, the measured values must be within 10%. The burner position can be adjusted by moving the burner frame relative to the sample frame to alter the offset to give the desired distribution and so the sample angle remains at 15° and the gap between the sample (x=0mm) and the face of the burner remains at 125mm.

Prior to the flame spread tests, this procedure was repeated for the desired peak heat flux level, so the distribution along the sample was known.

The average of 3 calibration runs over 3 days is shown in Figure 18 and Figure 19. The flux profile matches the standard profile well, although the cause of slightly higher value at 350mm is unknown.

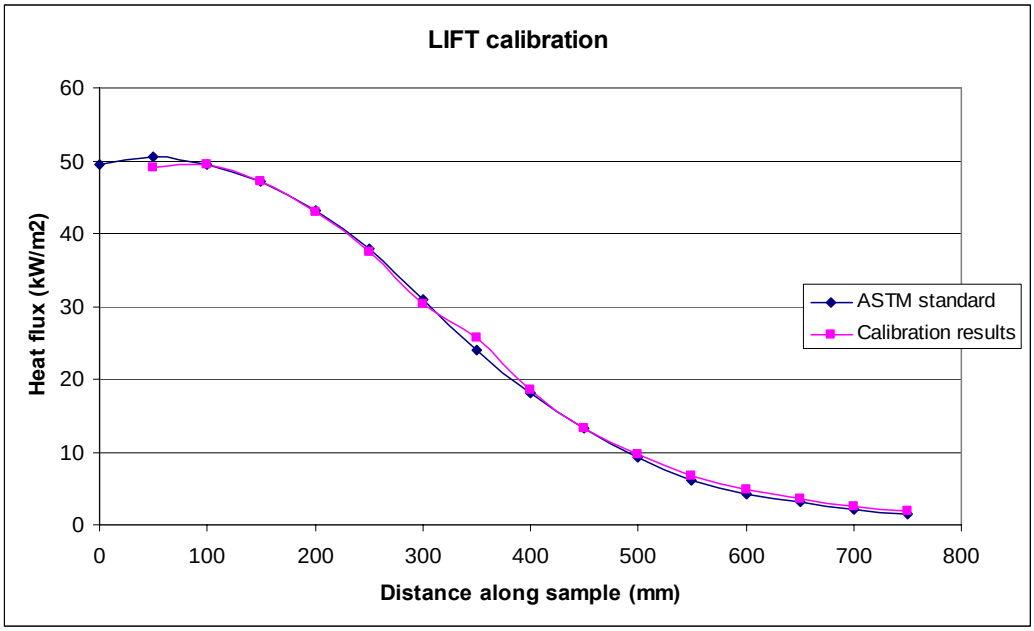



**Figure 18: LIFT calibration profile**

From 600mm onwards, the calibration results are outside the 10% limit (Figure 20), however this is beyond the limit of flame spread along the sample for the materials tested, so was not considered to be important. The results of the ASTM E 1317/ IMO resolution A.653 (16) interlaboratory round robin comparison (Pauner, 2003) showed a similar level of variation at the cold end of the sample at the same reference $\dot{q}''_{50mm}$ heat flux. The tests published by Nisted (1991) and Babrauskas and Wetterlund (1999) also had this issue and adopted the same approach. Due to the low flux levels at the cold end of the sample, the absolute error is less than the percentage variation would indicate.

Since the heat flux gauge was held flush with the surface of the measuring template, it records the radiative and a convective component to the total heat flux at the point. Dietenberger (1995c) showed the convection coefficient along the sample varied with position, and hence the convective component diminishes along the sample. Dietenberger recorded a bias up to 13% at the 750mm position for this reason.

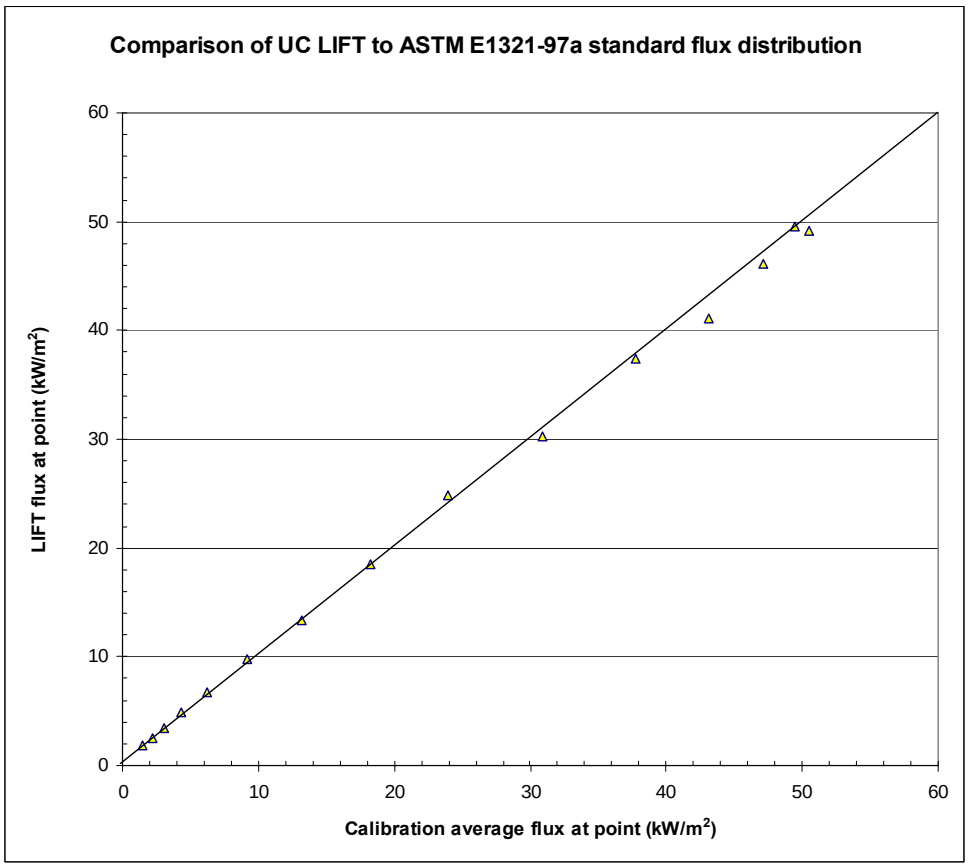



**Figure 19: Comparison to UC LIFT calibration flux to ASTM E 1321 standard**

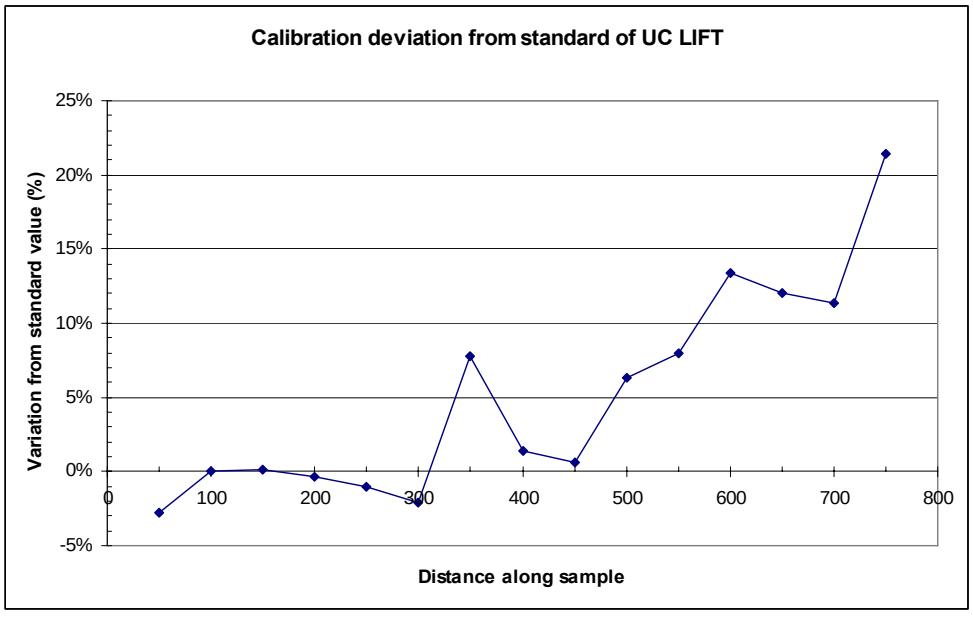



**Figure 20: Variation from standard for calibration of LIFT**

### 3.3.4 Heat flux from the pilot flame

The heat flux from the pilot flame to the sample was measured at the $\dot{q}''_{50mm}$ position, without the main burner running. The net increase of heat flux to the sample is given in Table 2. The effect of any draft or buoyancy driven updraft was noticeable, with an increase in the net heat flux to the sample of 50%, as the flame moves away from the backing flange. The effect of the pilot burner on the ignition time is within the variation of the experimental error, and variation of the burner output, so cannot be considered a significant source of error.

| | |
|---|---|
| Average flame heat flux | 0.14 kW/m$^2$ |
| Background flux | 0.03 kW/m$^2$ |
| Net heat flux from flame to sample | 0.11 kW/m$^2$ |

**Table 2: Pilot flame flux to sample**

## *3.4 LIFT Operating Procedure*

The operating procedure for the UC LIFT is given in Appendix 1. The effect of moisture content in the LIFT test is controlled by conditioning the samples at 50±5 % RH and 23±3°C until the product weight stabilises so that the change in mass over a 24hour period is less than 0.1% of the sample mass. All materials used in the experiments conducted in this report were conditioned for at least two weeks, with the conditioning room and laboratory conditions being at the lower end of the allowable range. No oven drying calculations were conducted to get the moisture content of the materials; however Simpson and TenWolde (1999) provide data for the typical moisture content of wood in equilibrium with the surrounding air. For the allowable range given in the ASTM LIFT standard, then the moisture content of the natural timber samples would be between 8.5% and 9.9% MC. The data from Simpson and TenWolde (1999) does not specifically address particle board or Meltica boards, where the high adhesive content may cause some difference to the equilibrium moisture content.

### 3.4.1 Ignition test

The LIFT test comprises of 2 parts, the first is an ignition test where the time to piloted ignition $t_{ig}$ is obtained for various heat fluxes $\dot{q}''_e$, and the minimum heat flux

for ignition ($\dot{q}''_{ig,\min}$) is obtained by bracketing the ignition results to find the lowest flux which will cause ignition within 20 minutes. The critical heat flux for ignition ($\dot{q}''_{crit}$) is obtained by plotting $1/\sqrt{t_{ig}}$ against $\dot{q}''_e$, and the critical heat flux is given by the intercept with the $\dot{q}''_e$, axis. The minimum heat flux for ignition ($\dot{q}''_{ig,\min}$) is given by plotting the time to ignition vs. heat flux and the curve will asymptote at the value for $\dot{q}''_{ig,\min}$.

Samples, 155 x 155 (+0,-5)mm were conditioned before the tests so that successive weighings, taken 24 hours apart, did not vary by more than 0.1% of the mass. The readings of the temperature and humidity in the conditioning room during the conditioning period indicated that they were generally at the lower end of the allowable range of 23°C ± 3°C and a relative humidity of 50% ±5%. The samples had the edges and back covered in aluminium foil during the test to reduce heat loss, and an insulated backing board is used. (Figure 21)

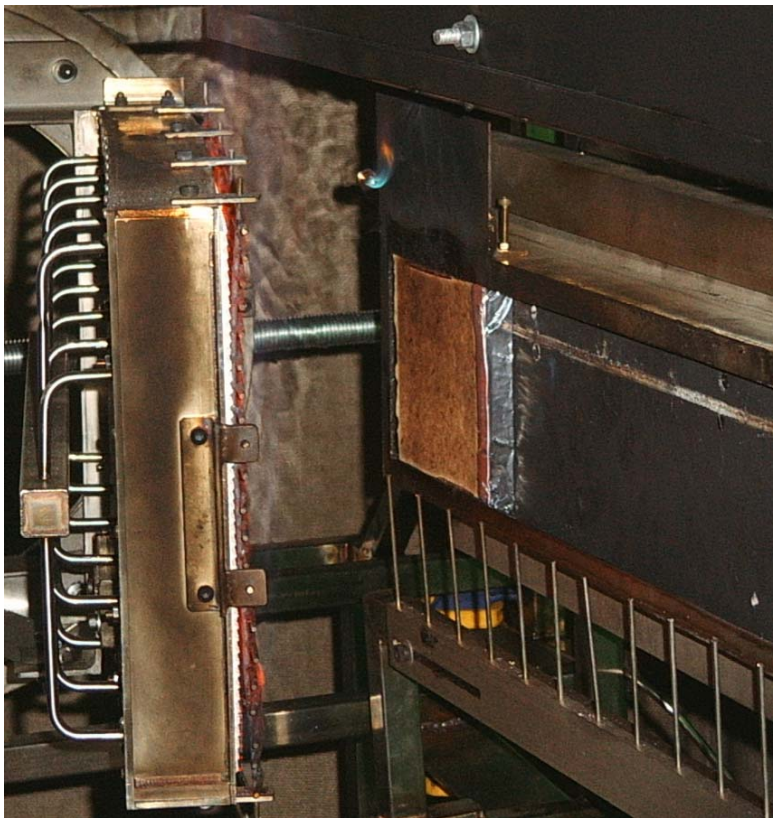


**Figure 21: Ignition test of particle board in LIFT**

The heat flux level at the sample face was measured using a water cooled heat flux gauge and the measuring template, which was fitted to a sample holder frame. The flux measurements for the ignition tests are conducted at the 50mm position – i.e. 50mm from the edge of the flange on the front face of the sample holder frame. After lighting the pilot burner and main burner, the pilot burner was adjusted to give a flame approximately 180mm long, and after the burner was allowed to equalise for 5 minutes, the flux output was adjusted to give the desired flux level at the 50mm position on the flux measuring template. The equipment was allowed to stabilise to give a constant output prior to testing.

The sample was wrapped with foil on the back and sides and placed with an insulated backing board in a second sample holder The measuring template was removed and within 10 seconds the sample was slid into place and timing started.

Once the sample ignited, it was removed and extinguished, the burner was adjusted to the next flux level, again using the heat flux gauge and template, and the burner was left to stabilise prior to testing the next sample.

A series of tests was done at varying heat flux levels to bracket the minimum flux for ignition to within 2kW/m$^2$, and up to the maximum that the burner could deliver.

### 3.4.2 Analysis of the ignition test

The basis for the ignition analysis is the ignition theory of Quintiere et al (1983) given in section 2.2.1.

Using the ignition data as above, the time to ignition ($t_{ig}$) versus heat flux ($\dot{q}''_e$) was plotted. The graph asymptoted to the minimum ignition flux ($\dot{q}''_{ig,\min}$) with a time to ignition limit of 20 minutes.

The (minimum ignition heat flux / incident heat flux) ($\dot{q}''_{ig,\min}$) / ($\dot{q}''_e$) versus $1/\sqrt{(t_{ig})}$ was plotted and a best fit line through the origin was overlaid on the data. As discussed in the following section, values where ($\dot{q}''_{ig,\min}$)/ ($\dot{q}''_e$)/ >0.8 were ignored as discussed below, if it significantly improved the fit of the data. This was a matter of engineering judgment as to the effect of these outliers due to the long heating times before ignition.

The point at which the best-fit line passes ($\dot{q}''_{ig,\min}$)/ ($\dot{q}''_e$) = 1 is the square root of the preheat time $t^*$ for the flame spread test – i.e. $\sqrt{(t^*)}$ . The slope of the best fit line was the ignition parameter "*b*", and this was used to solve for $k\rho c$, the thermal inertia using equation (14).

*Reduction of ignition data*

Since the behaviour of the material changes as the heating time increases, the fit of the data for the correlation to a straight line becomes increasingly less accurate, in particular for the data used in Quintiere et al's method. The values which best reflect the thermal inertia are those at the higher heat fluxes with the corresponding shorter ignition times. For the most accurate result, some of the data for points close to the minimum ignition flux must be ignored. The problem is that the choice of acceptable

data points is not clearly defined, a problem that has occurred for other researchers in the past:

> "From the examples shown in Figure x1.2 of the (ASTM E 1321) standard, it is clear that the sloping-line segment should follow only the initial set of data points. Data points for large values of √t are not to follow the sloping-line segment, but rather should end up fitting the subsequent horizontal line segment. Unfortunately, the standard gives no guidance as to how this is to be done. In our study, we inspected the individual data points and excluded as many from the high end of the time scale as did not follow the same slope as the data points on the left side of the graph…
>
> …. This process is clearly dependent on the judgement of the individual doing the data reduction. This means that, *starting with the same raw data*; two different operators can produce different values of reduced data."
>
> (Babrauskas and Wetterlund, 1999, page 23)

Attempting to define the limit for this report, based on the thermal penetration depth using equation (3) did not give a definite cut-off for acceptable data, especially if there was some scatter. In order to provide consistency, the data was plotted and a regression fitted to the data and the result was visually inspected. As a guide, points above $(\dot{q}''_{ig,\min}) / \dot{q}''_{e}$ >0.8 could be discarded if it significantly improved the fit of the data. This value was chosen as it encompassed the values close to the minimum ignition flux where the deviation was the greatest.

The $R^2$ correlation coefficient calculated by the spreadsheet for the fit of the data was used as a guide to what was deemed a "significant" difference. When considering whether to include a data point, it is again arbitrary, but if the $R^2$ value improved by more than 0.15 by excluding a data point, then this was deemed to be significant, and the value could be deleted. The difference was generally obvious from visual inspection.

The choice of which data points to include can have a significant effect on the ignition parameter "*b*" and particularly the preheating time $t^*$.

### 3.4.3 Flame spread test

Samples, 800 x 155 (+0,-5) mm were conditioned before the test as above. The samples had the edges and back covered in aluminium foil during the test to reduce heat loss, and an insulated backing board was used.

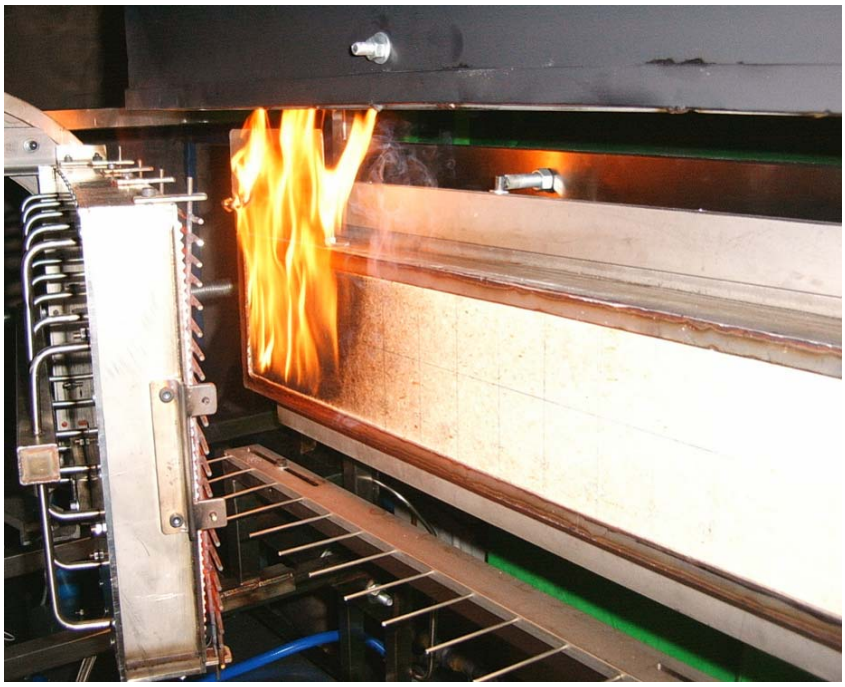


**Figure 22: Flame spread test**

Using a lead pencil, a line was scribed along the centre of the sample, in the long direction, with intervals marked at 25mm spacing, starting at the flange of the sample holder.

After igniting the pilot burner and main radiant panel burner, the pilot flame was adjusted to approximately 180mm long, and the radiant panel output to approximately 5-10kW/$m^2$ over the minimum ignition flux level calculated in the ignition test For the material being tested. The panel was left for 10 minutes to stabilise prior to starting the test. The flux levels at 50mm intervals along the sample were measured, using the flux gauge and measuring template, and then the pilot burner was turned off.
The sample holder containing the measuring template or dummy sample was removed and within 10 seconds the sample holder containing the test specimen was slid into

place and the timing started. If the sample did not ignite within the preheating time $t^*$ calculated from the ignition tests, then the pilot burner was lit or the sample was ignited at the bottom of the hot end using an hand held flame.

The time of ignition was recorded and the spread of the flame front was timed along the sample, using the reference points marked on the sample, or by using the viewing rakes and observation mirror.

As the flux level is effectively constant over the first 150mm of the sample, the flame spread very rapidly over this section. If it was extensively charred from a long preheating period, then it was difficult to ignite using the pilot burner, in which case, a small pilot flame was applied directly to the hot end of the sample.

### 3.4.4 Analysis of flame spread results

The analysis for the material properties is given in section 2. As noted by Babrasukas (1995), the units used in the flame spread calculations are inconsistent. The sample measuring positions are given in millimetres along the sample, but the calculation of the flame spread parameter value ($\phi$) requires the velocity to be in metres/second. The calculation in this case changed the velocities to metres/second.

The velocity of the flame front is calculated using a three point least squares fit calculated from the distance and time results of the nominal point and the points behind and in front – i.e. $x_n$, $x_{n-1}$ and $x_{n+1}$ using Equation (35) to get the average at the point.

$$V_f = \frac{\Sigma(t.x) - \frac{\Sigma t \Sigma x}{3}}{\Sigma t^2 - \frac{(\Sigma t)^2}{3}} \qquad \textbf{(35)}$$

*F(t)* was calculated for each interval along the sample, where *F(t)* = 1 if the time from inserting the sample was greater than the equilibrium time $t^*$.

A graph of $1/\sqrt{V_f}$ on the y-axis against ($q_e''$ . *F(t)*) on the x-axis was plotted and a regression line was fitted to the data (Figure 23)

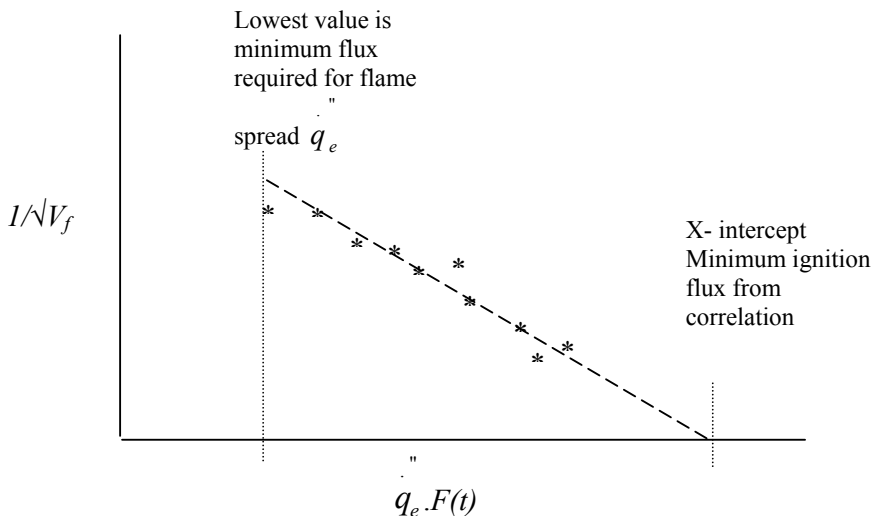



**Figure 23: Flame spread correlation graph**

The lowest value of $\dot{q}''_e.F(t)$ gave the minimum heat flux for flame spread ($\dot{q}''_s$), as an alternative to the heat flux at the point of the extent of flame spread on the sample during the test.

The point at which the regression line crosses the x-axis gave an alternative means of calculating the minimum ignition flux $\dot{q}''_{ig,\min}$. Note that strictly speaking, the value of $\dot{q}''_{ig,\min}$ was an experimental result, whereas the value from the graph was a correlation, so some difference in the result was expected.

# 4 The cone calorimeter

The cone calorimeter was developed by the National Bureau of Standards (now National Institute of Standards and Technology), part of the US Department of Commerce, in 1982. It was a radical departure from previous heat release measuring systems, and attempted to eliminate some of the problems that previous methods had (Babrauskas, 1993). It was adopted as an ISO standard (ISO5660) in 1992, and forms the basis of an increasing number of legislative tests (Babrauskas, 1992) and models of other standards, such as the ISO 9705 room-corner test (Beyler et al, 1999) and the ASTM E 84 "tunnel" flame spread test (White and Dietenberger, 2004).

Conceptually, it is a simple method, but gives the ability to produce a lot of data with a high degree of automation in the data collection. It has a conical element, which gives the device its name. For conventional fire testing, a sample, generally 100mm*100mm is mounted on a load cell, so that the mass loss during burning can be recorded. The sample is exposed to a heat flux, up to 100kW/$m^2$, and the heat release rate, mass loss and toxic gas production is recorded. Further enhancements have included measuring the smoke production, opacity and the effect of atmosphere (vitiated or oxygen enriched) on the burning behaviour.

There are a number of key features that make it different from other methods of bench scale fire testing (Figure 24). Most obviously is the use of the conical electric element. Most other devices of this sort at the time used flat panel radiant elements, generally gas fired. Using an electrical element eliminated the need for the fragile refractory ceramic tiles and gas supply, and gave a more consistent control. More importantly, it allowed testing to be done in the horizontal position, particularly for melting materials. The conical shape gave an almost constant heat flux across the face of the sample, yet allowed the smoke and combustion products to escape without interfering with the radiation from the element.

The combustion products are collected in a hood, and sampled to measure the oxygen, carbon monoxide and other gas levels. The heat release rate is calculated using oxygen consumption calorimetry, whereby the amount of oxygen consumed by the combustion is measured. The heat released per mol of oxygen consumed is effectively constant at 13.1kJ/kg and hence by measuring the oxygen consumed, the heat release

rate for the sample can be calculated. As the sample is mounted on a load cell, the heat release rate can be compared with the mass loss and an effective heat of combustion can be determined.

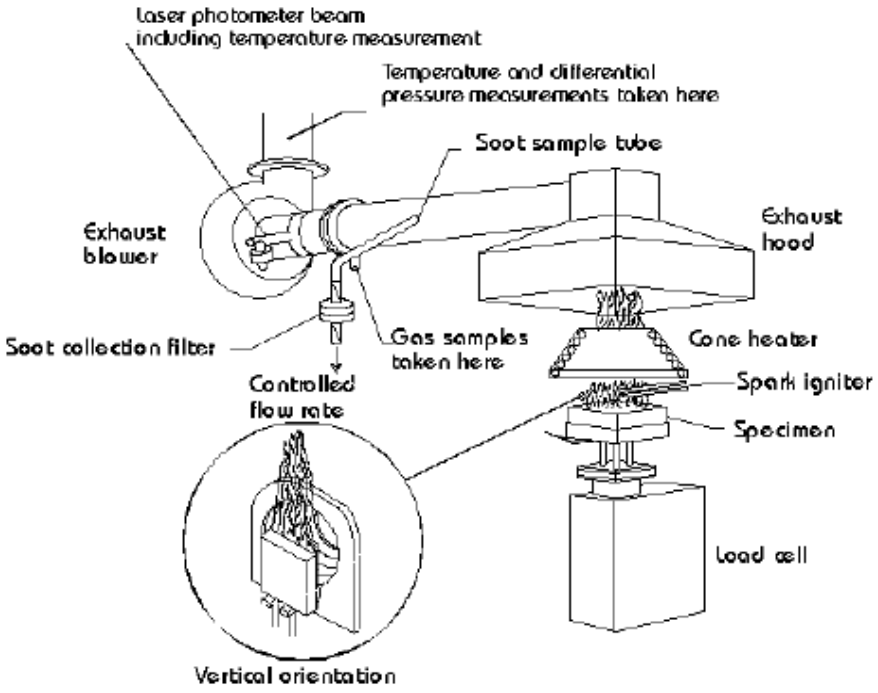



**Figure 24: Cone calorimeter (reproduced from Babrauskas, 2002)**

The pilot ignition is by a spark gap, and the position of this is adjustable to be centred in the middle of a horizontal specimen, or at the top of a vertical specimen.

A key advantage of the cone calorimeter against tests such as the LIFT is that the data collection is automatic and extensive, hence more data can be collected, the tests are faster and the results do not require as much judgement or manipulation. The cone calorimeter has successfully been used to model a variety of other tests and standards, giving good results for well behaved materials, such as timber products (Janssens, 2005). Thus far, efforts to model lateral flame spread using only cone calorimeter data (Jianmin, 1990) have generally not been successful (Goransson, 1991, Persson, 1993).

While the RIFT as tested here is only concerned with ignition and flame spread, Azhakesan et al (1998) used the RIFT data in conjunction with mass loss readings and calorimetry to give a simultaneous heat release rate as part of a room fire model.

# 5 ISO 5657-1987 Ignition test

The ISO 5657 apparatus was originally designed in 1970 in the Experimental Building Services in Australia, now part of the CSIRO (Babrauskas, 2003). The ISO 5657-1987 ignition apparatus is similar to the cone calorimeter, in that it uses a conical electrical element, although the size and shape is slightly different. The element is electronically controlled via a thermocouple controller with a maximum heat flux to the sample of 50kW/m$^2$.

. The standard ignition method was part of the original British Standard BS 476: 1987: Part 13, from which the ISO 5657-1987 standard is derived. This originally used a small pilot flame, which is dipped above the sample at 4 second intervals – giving a resolution of ±2 seconds. The ignition in the University of Canterbury ignition apparatus is now a spark, similar to the cone calorimeter, to give a more accurate time for ignition. The pilot flame apparatus, seen on the centre of Figure 25, is still present but was not used for these experiments, or those by Ngu (2002).

The test differs from the cone calorimeter in that it uses a weighted platform with a counterweight (seen on the right side of Figure 25) to hold the sample against a flat plate with a circular cut-out, in order to provide a consistent distance from the sample to the element, even if the top of the sample shrinks away. The sample size is also larger, using a 165mm square sample, instead of the 100mm sample used in the cone calorimeter. In both cases, the sample is backed by an insulating board. Only a circular area of 150mm diameter of the sample is exposed the element, with the remainder of the sample shielded by the flat plate.


**Figure 25: ISO 5657 ignition apparatus**

The sample is wrapped in aluminium foil. The BS476: 1987 Part 13 standard calls for the top of the sample to be covered with aluminium foil, with a circular cut-out, to prevent the plate from being soiled by residue.

A shield is used while the sample is being placed in position, shown on the bench in Figure 25, which is removed and timing started until the sample ignites, or the test duration is over. Replacing the shield extinguishes the burning sample which can then be removed.

# 6 Reduced Scale ignition and flame test (RIFT) method

The RIFT method is a result of research published by Azhakesan et al (1998) at FireSERT in Ulster, Northern Ireland. The objective was to provide an alternative to the standard LIFT test for spread-of-flame measurements, by using a modified cone calorimeter, rather than requiring the ASTM1321 LIFT test apparatus. The results published from Azhakesan et al (1998) showed some success.

Further work was done at the University of Newcastle by Pease (2001) and by Huynh (2003) from the University of Canterbury. These results were inconclusive and showed a lack of resolution in the measurements. The principal problem was identified as the location of the sample, where the hot end of the sample was on the centreline of the cone (Figure 26), so only half the heat flux from the cone was available. The resulting flame spread was in the order of 90mm along the sample (Huynh 2003), and the resolution was insufficient to give accurate data.

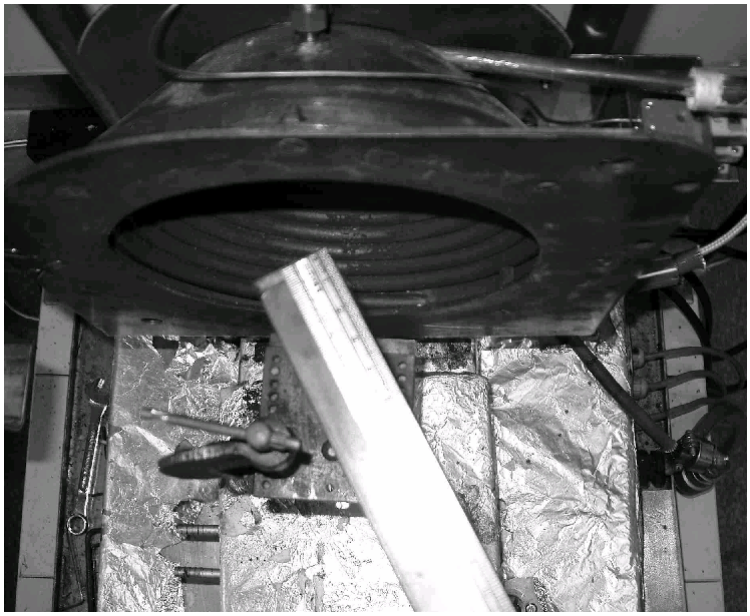


**Figure 26: Australasian RIFT test, showing location of sample to the cone (reproduced from Huynh, 2003)**

The angle of the sample in the tests in Australia (Huynh 2003, Pease 2001) and Ulster (Azhakesan et al 1998) was at 60 degrees to the cone heater element face, compared

with 15 degrees for the conventional LIFT test, which uses a larger flat panel element. The sample size chosen was 100 x 350mm in Ulster, and 100 x 250mm in Australia.

### *6.1 Comparison between RIFT and LIFT*

The LIFT uses a sample angle of 15 degrees with a flat radiant gas panel instead of the conical element of the RIFT and the LIFT burner panel size and the sample size are in the order of three times larger than those used in the RIFT.

The effect of the smaller scale of the RIFT is shown in Figure 27 where the sample angle and peak heat flux is set at the same values for both sets of apparatus. The heat flux decays more rapidly in the RIFT as the measurement moves away from the element, due to the directional nature and smaller size of the cone and consequently the smaller size of the sample. .

Comparing the heat flux of the RIFT with the LIFT shows that the potential peak heat flux is less (the LIFT has a peak up to 50kW/m$^2$) and the heat flux diminishes more quickly with the RIFT. The peak heat flux for the RIFT is largely dictated by the available cone element temperature. A maximum temperature of approximately 850°C was chosen in the interests of a longer element life. Increasing the peak heat flux level does little to increase the effective flame spread length. This is discussed in more detail in Section 6.3. This is due to the directional nature of the cone element.

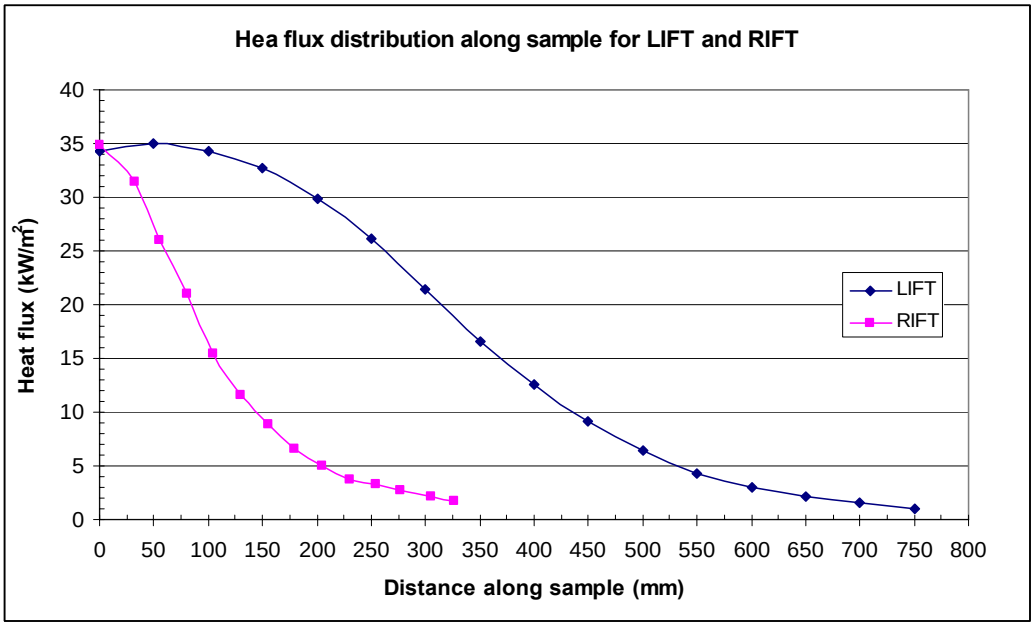



**Figure 27: Heat flux for LIFT vs. RIFT (both at 15 degree angle)**

## *6.2 Procedure for using RIFT*

The procedure for using the RIFT apparatus is based on the ASTM1321 standard and follows the same methodology. The rear and sides of the samples are wrapped in aluminium foil and a 12mm Kaoboard insulating board is used behind the sample. The sample is inserted, with timing starting once the sample is in place against the end of the sample frame. The retaining screws at the rear of the sample frame are tightened to press the sample against the front flange.

### 6.2.1 Setup of RIFT

The cone calorimeter element was set to the vertical position and the long axis centreline of the RIFT sample holder was inline with the centreline of the cone. The end of the sample closest to the element was in line with the edge of the element, as shown in Figure 28.

The angle and sample separation distance $x_0$ was set by measuring perpendicularly from the face of the cone to the sample, as shown in Figure 28 and Table 3.

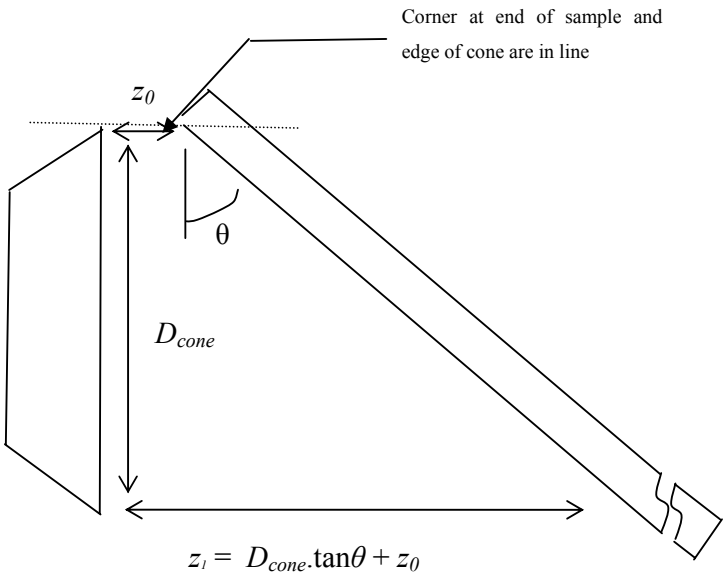



**Figure 28: RIFT setup – plan view**

The standard RIFT setup is in Table 3.

| | |
|---|---|
| Angle of sample | 60 degrees |
| Separation of sample from face of element ($z_0$) | 45mm |
| Peak heat flux (0mm along sample) | 35kW/m$^2$ |
| Typical cone temperature | 850°C |
| Cone diameter $D_{cone}$ | 160mm |

**Table 3: RIFT setup dimensions**

The sample holder must be level and parallel to the face of the cone element, when viewed in elevation.

### 6.2.2 Sample preparation

The same protocol was used as required by the ASTM E1321-97a LIFT standard , which calls for samples to be conditioned at 23°C ±3°C and a relative humidity of 50% ±5% so that successive weighings, taken 24 hours apart, do not vary by more than 0.1% of the mass. For the flame spread test, the samples had the back and sides covered in aluminium foil to limit moisture loss from the sample.

### 6.2.3 Flux measurement

The heat flux measurement along the sample was conducted using a template made from fibre cement board with location holes at 25mm centres to take the head of a water cooled flux measuring gauge and this was inserted in into the sample holder (Figure 29 and Figure 30).

After turning on the cone element and extraction hood, the cone element was brought up to temperature with 5 minute stabilisation breaks at 400 and 600 degrees, before increasing to the final temperature. The element was running at the final temperature for at least 10 minutes before any readings are taken to allow the temperature of the element and apparatus to stabilise. After checking that there was water flow through the heat flux gauge before taking any heat flux readings, the head of the flux gauge was inserted into the template, ensuring that the face of the heat flux gauge was flush with the face of the template and not inside the hole to ensure accurate readings of the incident flux at each point. The heat flux gauge was left in place for at least 30 seconds to allow an average reading of the heat flux over that time to be taken before moving to the next measuring point. As with the LIFT, and outlined in Section 10.1 having the head of the flux meter proud of the surface of the template at the cold end of the sample will improve the accuracy of the measurements due to the convection boundary layer.

The flux readings were compared with the required values from Figure 31 and the cone temperature was altered to give the best match.

A polynomial match to the final RIFT heat flux profile gives a 5th Degree Polynomial Fit: $y=a+bx+cx^2+dx^3$... with the coefficients given in Table 4.

| | |
|---|---|
| a = | 34.910273 |
| b = | -0.064334216 |
| c = | -0.0031889273 |
| d = | 2.6422166e-005 |
| e = | -8.0288574e-008 |
| f = | 8.6335299e-011 |

**Table 4: RIFT polynomial coefficients**

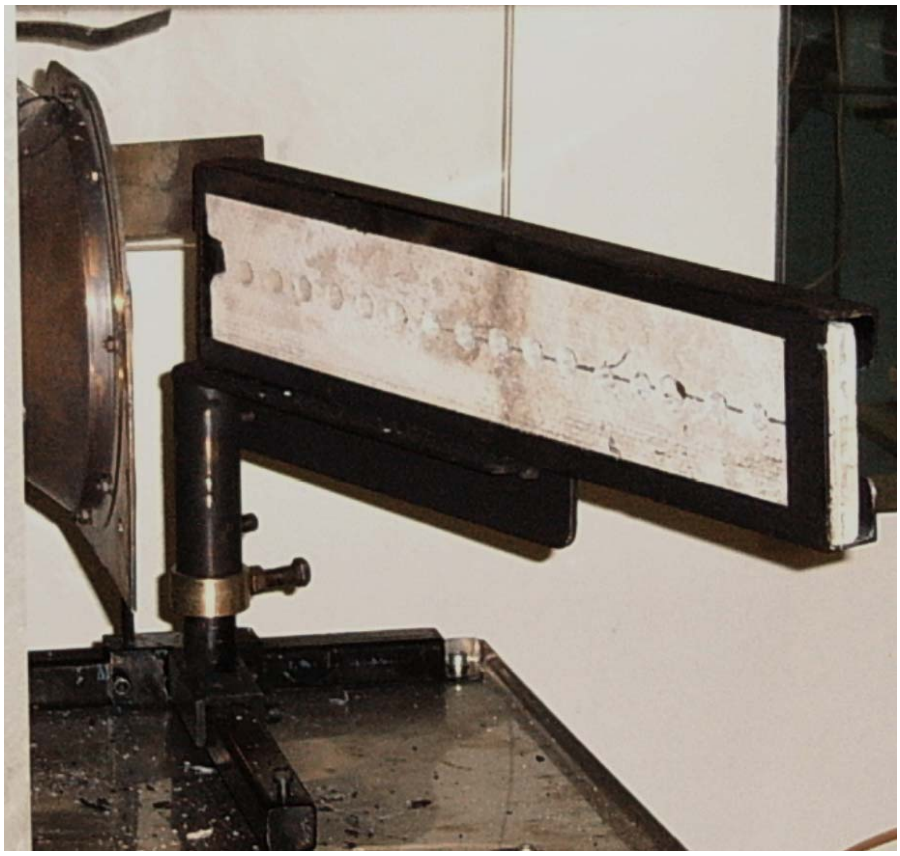


**Figure 29: RIFT with flux measurement template**

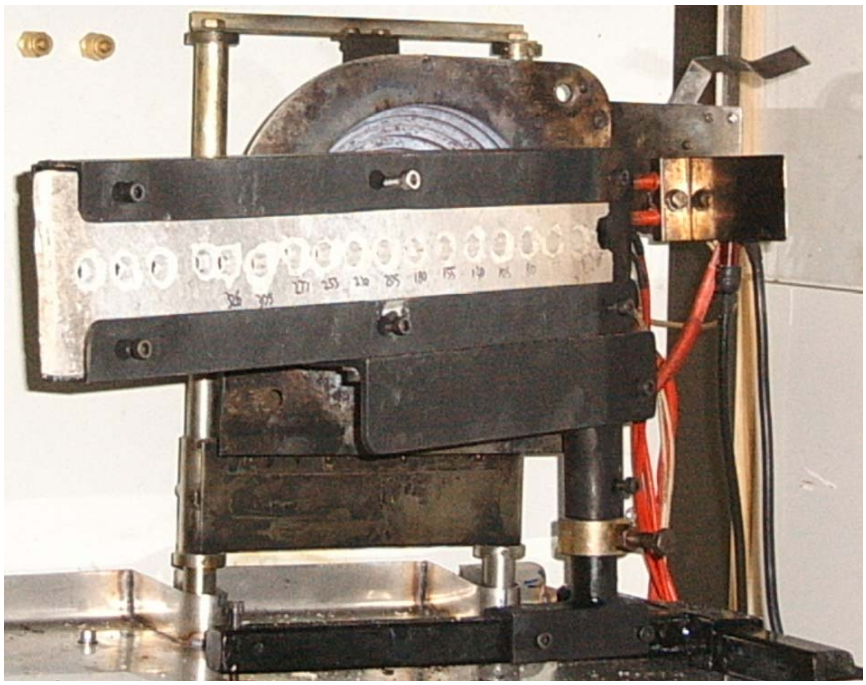


**Figure 30: RIFT sample holder from rear**

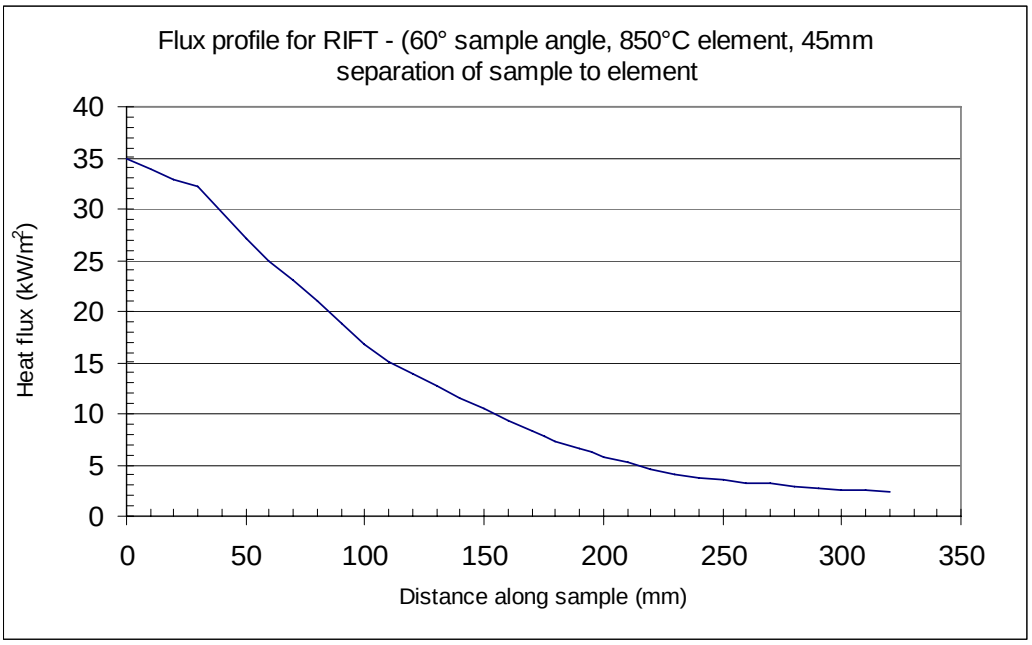



**Figure 31: RIFT irradiance curve for a sample separation of 45mm, 850°C element temperature and 60° sample angle**

### *6.3 Heat flux and sample angle in the RIFT*

The ASTM E 1321-97a standard test for measuring the spread of flame parameters calls for a peak heat flux 5-10kW/m$^2$ over the minimum ignition flux ($\dot{q}''_{ig,\min}$) from the ignition tests. For timber based products the peak heat flux would then be between 18-28 kW/m$^2$, given the minimum ignition flux is in the order of 13-18 kW/m$^2$ (Ngu 2002).

Azhakesan et al (1998) used a peak heat flux of 35kW/m$^2$, whereas Pease (2000) and Huynh (2003) used a 60kW/m$^2$, due to the different experimental setup, which only used half the cone width (Figure 26). The choice in the original tests of 35kW/m$^2$ was given as the typical heat flux to walls in a fire (Azhakesan et al (1998)).

### *6.4 The effect of different element temperatures*

The effect of changing the element temperature as a means of altering the received heat flux on the sample can be seen in Figure 32. The main result is the curve is

scaled with a correspondingly lower peak flux value. The point at which the minimum heat flux for flame spread occurs moves slightly towards the hot end of the sample, with little overall difference in the overall length of flame spread, as given in Section 6.7, due to the directional nature of the heat flux profile of the conical element.

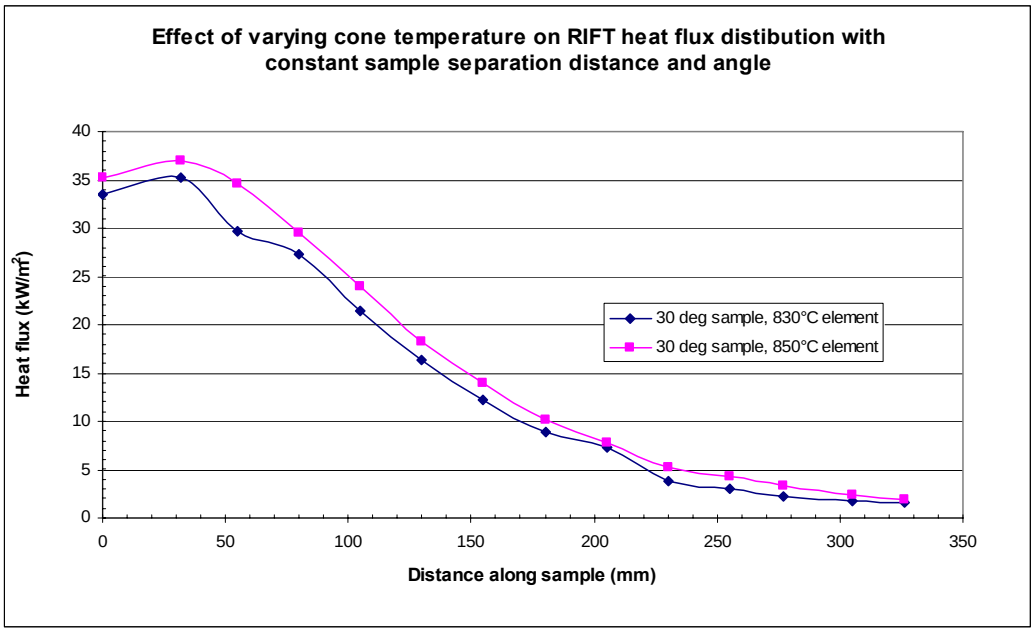



**Figure 32: Effect of changing cone element temperature on received heat flux (70mm separation, 30 degree sample angle)**

## *6.5 The effect of changing the sample angle*

The effect of a changing sample angle for a constant cone temperature on the received heat flux is shown in Figure 33. The decreasing angle increases the peak flux level, however does not significantly alter the minimum flux level or the point at which this occurs, due to the directional output of the cone element.

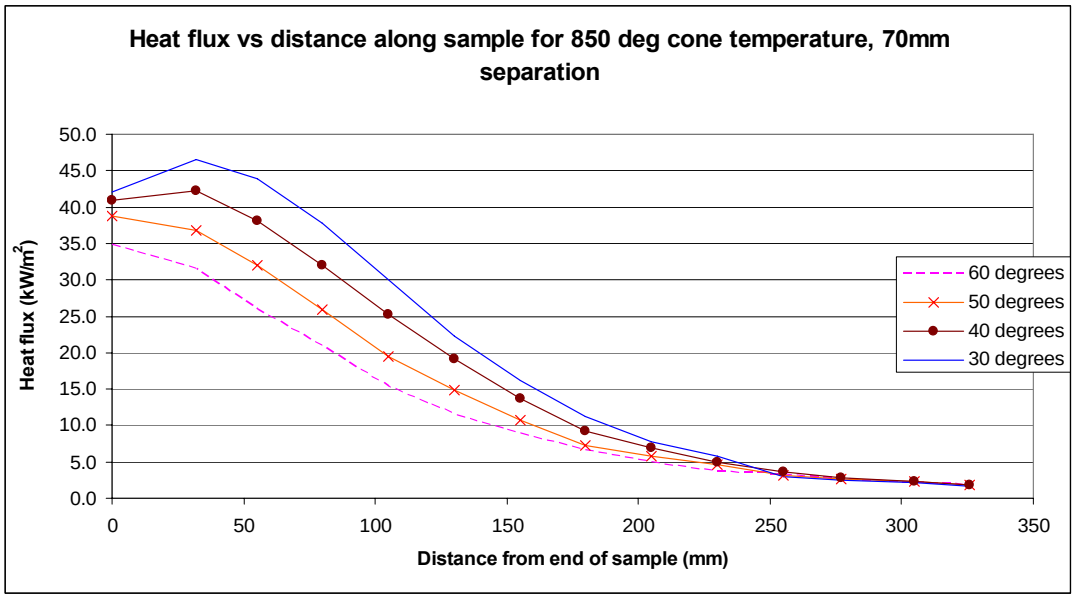



**Figure 33: Irradiance for a constant 850° element temperature, 70mm separation and changing sample angle**

More usefully, when the peak heat flux is kept constant by changing the cone temperature to suit, then the effect can be seen in Figure 34. The directional nature of the cone element can be seen by the location of the peak flux level along the sample, and the terminal heat flux, which remains relatively constant, despite the changing view factor.

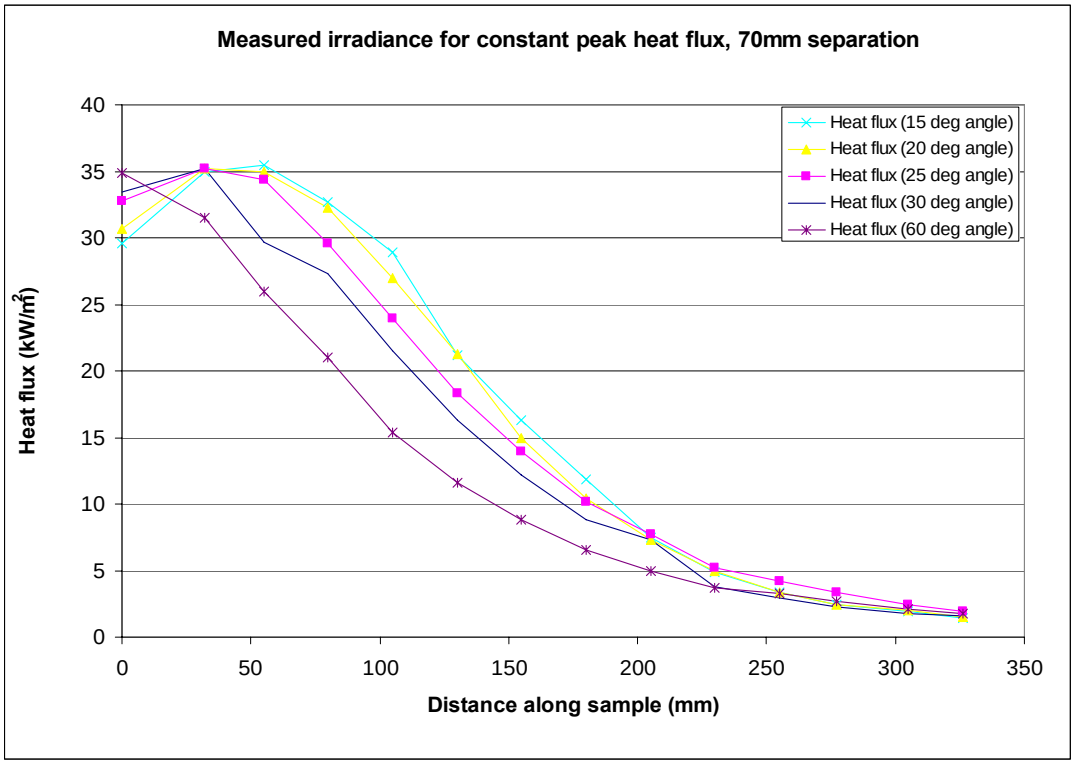



**Figure 34: Irradiance with constant peak heat flux of 35kW/m$^2$ and 70mm sample separation**

## *6.6 The effect of increasing the separation distance between the sample and element*

Increasing the distance between the sample and the element should increase the spread of the irradiance along the sample, giving greater resolution by allowing for a greater flame spread, as the minimum flux level for flame spread ($\dot{q}''_s$) is further along the sample. The directional nature of the cone element shows that this does not occur within the limitations of the desired heat flux level and element temperature.

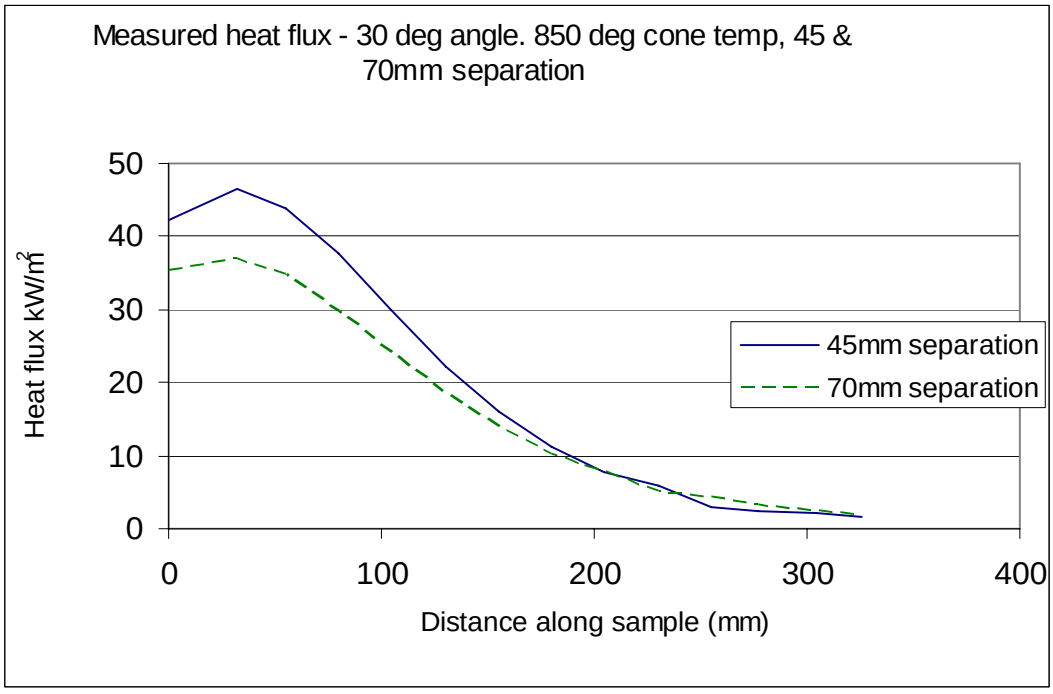



**Figure 35: Change in heat flux with constant element temperature and angle**

## *6.7 Optimum angle of sample in RIFT*

As the basis of flame spread measurements is to have a series of velocity vs. received heat flux measurements, it follows that the distance along the sample from the point of the peak heat flux ($L_{peak}$) to the point where the flame spread stops ($L_{spread}$) due to insufficient received flux, should be as long as possible, as shown in Figure 36

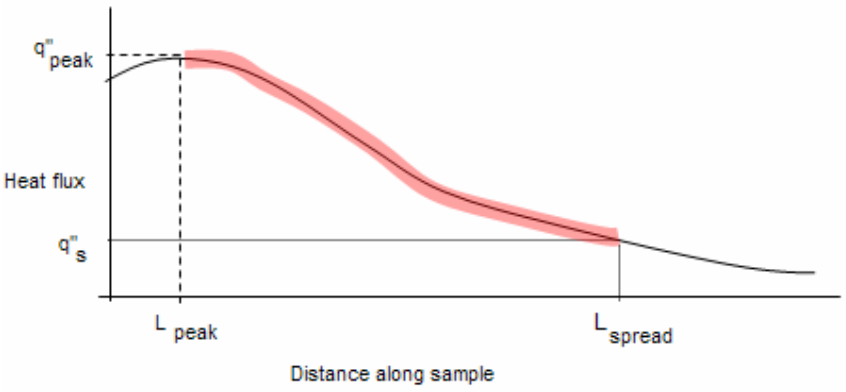



**Figure 36: Limitations for flame spread measurement**

The profile of the full scale LIFT test allows the apparatus to be used for ignition testing, as there is an almost flat heat flux curve for the first 150mm of the 800mm sample. This feature is not required in the RIFT, as the cone calorimeter or ISO 5657 ignition apparatus can be used for ignition testing in the conventional manner. The maximum distance along the sample, between the points $L_{peak}$ and $L_{spread}$ is when the peak heat flux coincides with the end of the sample, as the location of $L_{spread}$ remains relatively unchanged due to the directional output of the cone element (Figure 34). There is no advantage to having a plateau in the irradiance profile at the beginning of the sample, as the requirement is for different heat fluxes at each measuring point along the sample; hence the optimum angle chosen between the element face and the sample is therefore 60 degrees, as used by Pease (2001), Huynh (2003) and Azhakesan (1998).

## *6.8 RIFT test methods*

### 6.8.1 Ignition test

Previous studies involving the RIFT used either the cone calorimeter in the normal horizontal position (Azhakesan 1998, Huynh, 2003), or the ISO 5657 ignition testing apparatus (Huynh, 2003) to obtain the ignition data. Ignition tests were conducted using the RIFT (Figure 37) to see if it improved the correlation of the data to the LIFT results by having the sample in the same orientation.

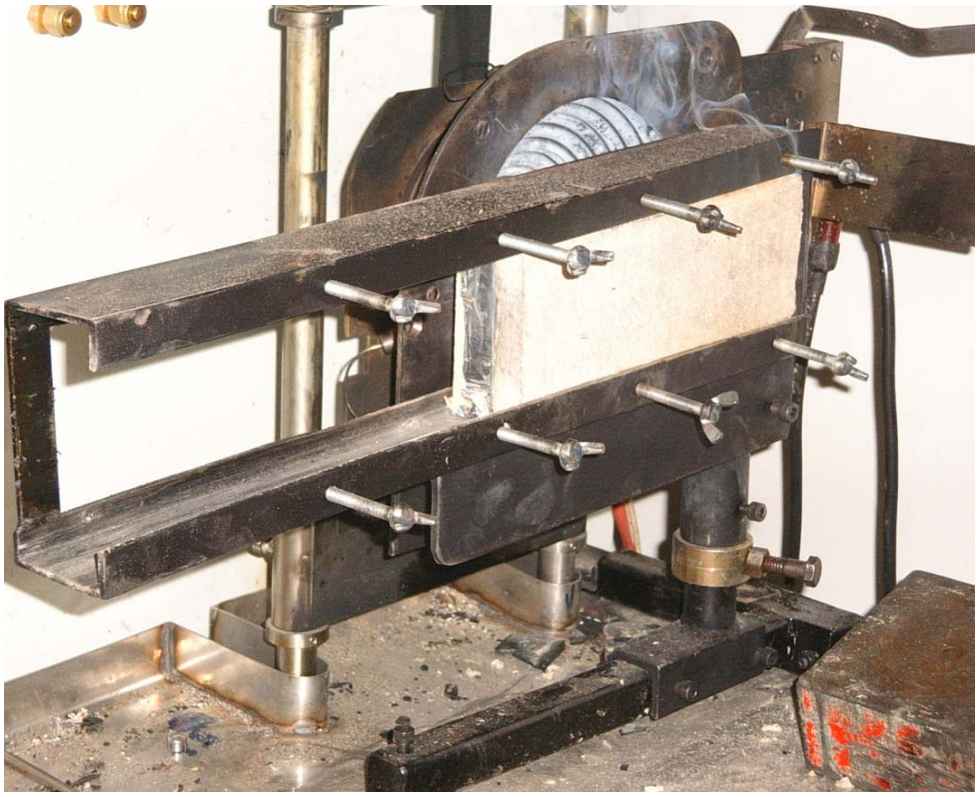


**Figure 37: Rift used for ignition testing - rear view**

The ignition test used 200 x 95mm samples with the sample holder mounted parallel with the face of the cone element. The spark igniter was level with the top of the exposed face of the sample, and 13mm from the sample face (Figure 38). The ignition test in the cone calorimeter uses samples 100mm x 100mm, with an insulated backing board and holder, and an electric spark pilot, mounted 13mm above the sample face, and the test is generally conducted with the sample mounted horizontally. The

ISO 5657 ignition apparatus is similar but uses a 165 x 165mm sample. The sample holder in the RIFT ignition test was set to the centreline of the cone, and the cone element set to give the required heat flux, measured with a template in the centreline of the cone element. The required temperatures matched those previously recorded for this cone element when used for ignition testing in the cone calorimeter.

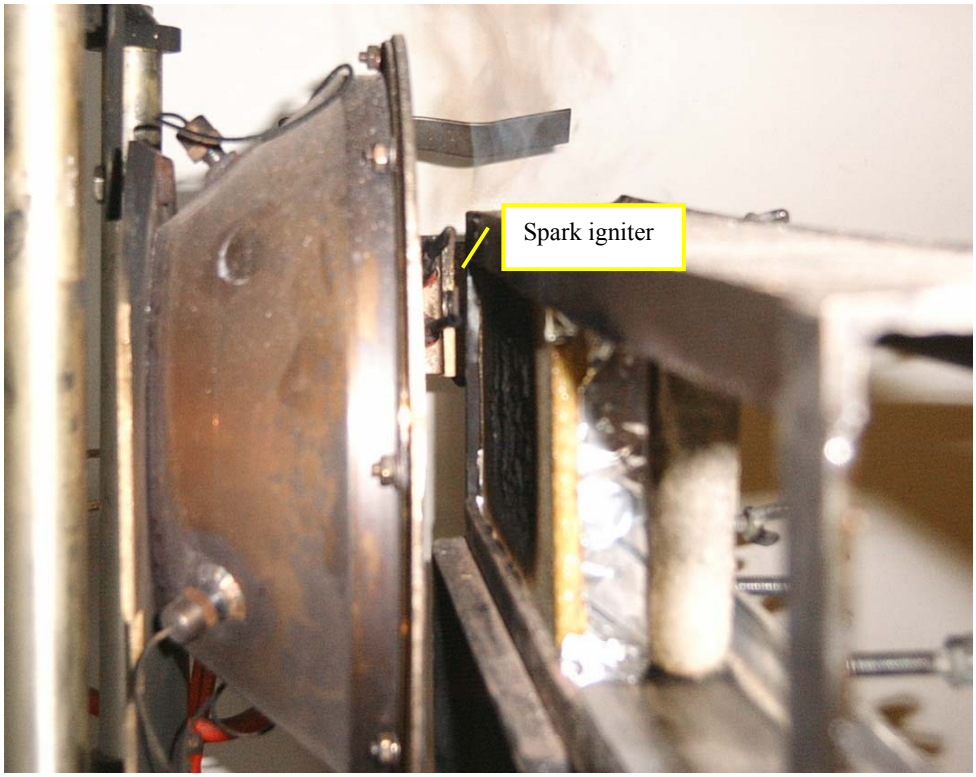



**Figure 38: RIFT used for ignition testing**

The sample was mounted parallel to the cone element, and exposed to a constant heat flux. In the same manner as ignition testing in the LIFT, cone calorimeter and ISO 5657 apparatus, the time to ignition was recorded, and then another flux level was chosen and the procedure repeated, until the sample did not ignite in 20 minutes.

The external irradiance ($\dot{q}''_e$) was plotted against the time to ignition ($t_{ig}$) to give the minimum flux for ignition ($\dot{q}''_{ig,\min}$) where the ignition time is effectively infinite. For thermally thick materials, the x-intercept of $\dot{q}''_e$ . vs. $1/\sqrt{t_{ig}}$ gave the critical ignition flux ($\dot{q}''_{crit}$)

### 6.8.2 Flame spread test

The samples were marked with a line in the centre of the face in the longitudinal direction, and across the sample every 10mm along the sample, to allow the flame spread to be measured during the test. The distance from the end of the sample was marked on the sample every 20mm.so the flame progress along the sample could be monitored.

The flux measuring template was removed and sample slid into place, with the timing started from the point at which the sample touches the end of the sample holder and the sample holder screws on the back of the sample holder were then tightened so that the face of the sample is pushed against the front flange. If the sample did not within the preheating time $t^*$, then a 25mm pilot flame was applied to the bottom corner of the hot end of the sample to ignite the sample. The time to ignition and the time taken for the flame front to reach each 10mm gridline, taken at the centreline of the sample was recorded. .

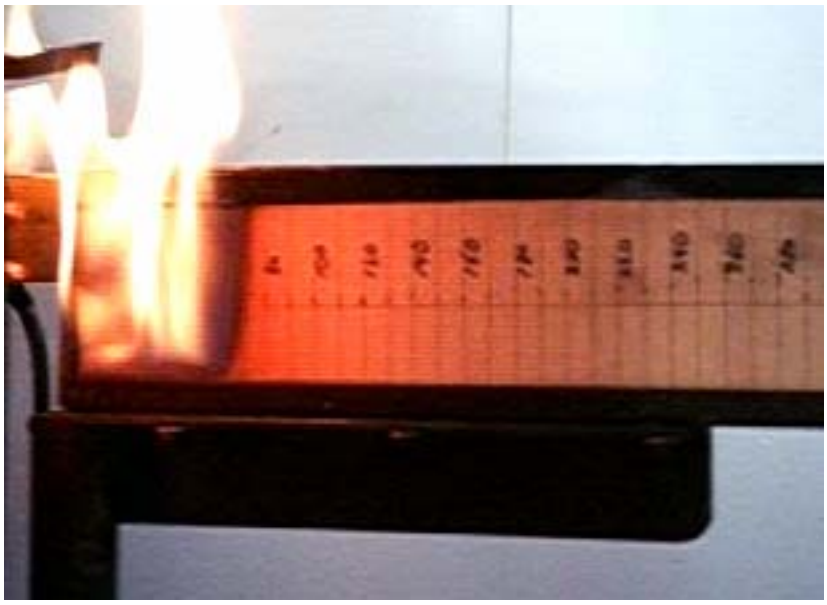


**Figure 39: Flame spread along sample**

The test was complete once the flame ceases to advance along the sample and extinguishes, or it reaches the end of the sample.

## *6.9 Calculation of the view factor for the reduced scale LIFT test (RIFT)*

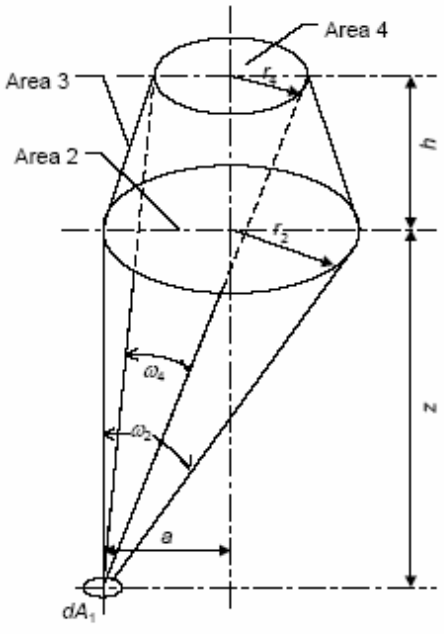
Some initial investigation into the view factor of the RIFT was done by Huynh (2003), but these were generally unsuccessful, due to the sample being positioned in the centre of the cone element, rather than at one edge. Huynh (2003) suggested that the view factor developed by Wilson et al (2002) for the cone calorimeter could be used to calculate a view factor for the RIFT, and that it may be more successful with the sample mounted fully across the face of the cone element. This has been investigated in the following chapter.

### 6.9.1 Wilson et al, 2002

Work by Wilson et al (2002) gave the heat flux received by a sample under the cone calorimeter as a function of distance from the cone centre, and the distance between the sample and the face of the cone element, given by equation (36) and equation (37) for the heat flux to a point on the sample.

The nomenclature of the geometry is as listed by Wilson (2002), reproduced in Figure 40.

| | |
|---|---|
| a | distance from centreline |
| $dA_1$ | Elemental area on the sample's surface |
| $H_2$, $H_4$ | $H_2 = z/a$<br>$H_4 = (h + z)/a$ |
| h | height of the frustum (given as 65 mm for standard cone) |
| q" | Local radiant heat flux on the sample surface ($W/m^2$) |
| $R_2$, $R_4$ | $R_2 = r_2/a$<br>$R_4 = r_4/a$ |
| $r_2$, $r_4$ | radii of the base and top of the frustum (80 mm, and 40 mm, respectively) |
| T | Average surface temperature of the heating |



element (K)

| | |
|---|---|
| Z | Distance from the lower base of the element frustum to the sample surface |
| $Z_2$, $Z_4$ | $Z_2 = 1 + H_2^2 + R_2^2$ <br> $Z_4 = 1 + H_4^2 + R_4^2$ |
| ε | Emissivity of the heating element (0.99) |
| σ | Stefan-Boltzmann constant, $5.67 \times 10^{-8}$ ($W/(m^2K^4)$) |

**Figure 40: Cone calorimeter view factor geometry (from Wilson, 2002)**

The heat flux to any point on the sample, offset from the centre of the cone element is given by Equation (36)

$$q'' = \frac{1}{2}\left[\left(1 - \frac{1 + H_2^2 - R_2^2}{\sqrt{Z_2^2 - 4R_2^2}}\right) - \left(1 - \frac{1 + H_4^2 - R_4^2}{\sqrt{Z_4^2 - 4R_4^2}}\right)\right]\varepsilon\sigma T^4 \qquad \textbf{(36)}$$

The heat flux to a point on the sample centre in the cone calorimeter in normal use is given in equation (37)

$$q'' = \left[\frac{r_2^2}{z^2 + r_2^2} - \frac{r_4^2}{(z+h)^2 + r_4^2}\right]\varepsilon\sigma T^4 \qquad \textbf{(37)}$$

where the temperature of the cone element is the average temperature of the element in Kelvin.

In the case of the RIFT, the separation z will vary along the length of the sample, as the sample is at an angle to the face of the element, shown in Figure 41.

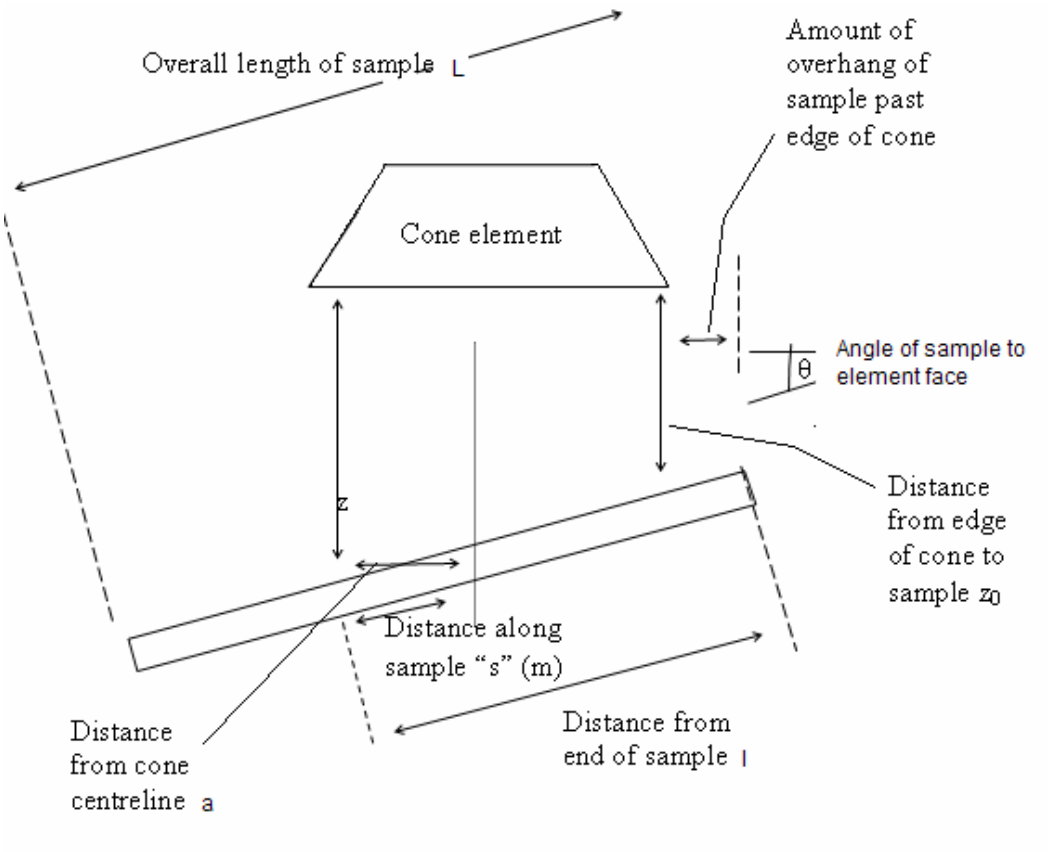



**Figure 41: RIFT geometry**

As the sample is at an angle to the element face, the heat flux received by the differential element $dA_1$ is reduced by the cosine of the angle between the sample and the heating element. The heat flux at a point on the sample is therefore given in Equation (38).

$$q'' = \frac{1}{2}\left[\left(1 - \frac{1 + H_2^2 - R_2^2}{\sqrt{Z_2^2 - 4R_2^2}}\right) - \left(1 - \frac{1 + H_4^2 - R_4^2}{\sqrt{Z_4^2 - 4R_4^2}}\right)\right]\varepsilon\sigma T^4 . \cos(\theta) \qquad (38)$$

The heat flux on the sample is limited by peak temperature attainable by the element, and this is taken to be 850°C. The distance between the sample and the element ($z_0$),

measured perpendicular to the face of the element at the closest edge is used as a measure of the separation of the sample from the element.

While Wilson (2002) showed reasonable accuracy for Equation (36) in comparison to measurements taken under the cone calorimeter in the horizontal position, with a sample parallel to the heater face, the relationship becomes increasingly less valid as the sample angle increases. The shape is generally correct, as shown in Figure 42; however the calculated values are significantly lower than the measured values.

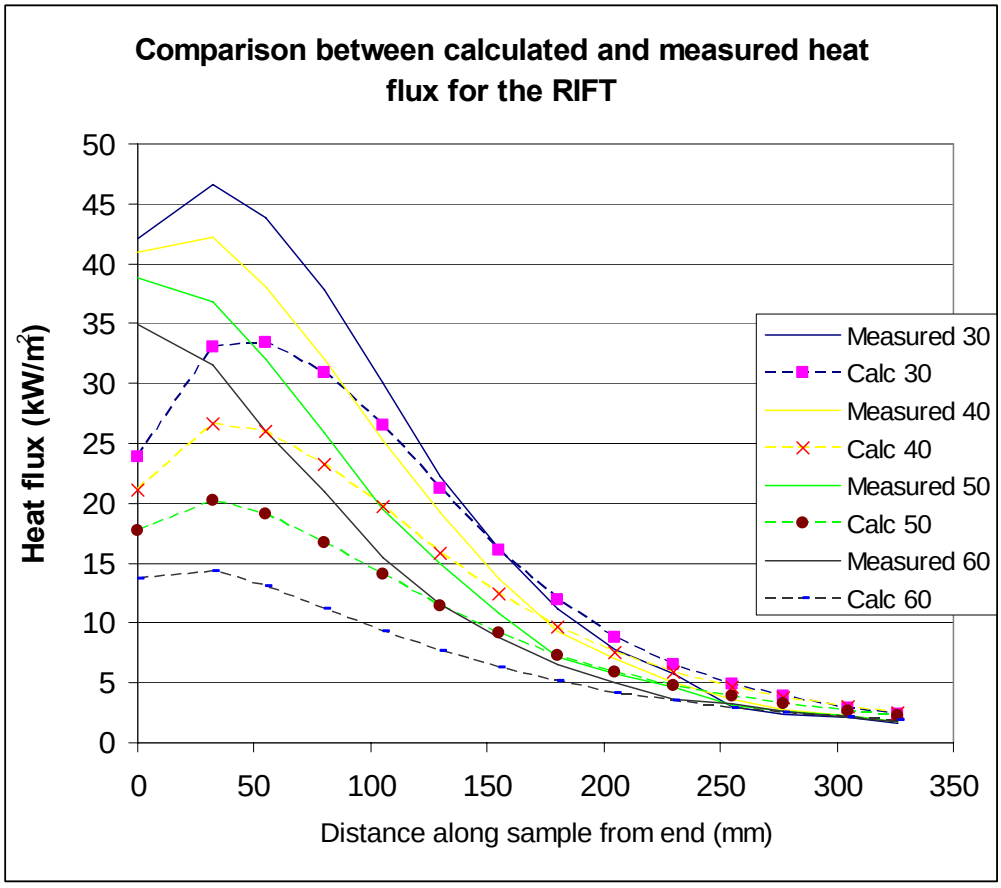



**Figure 42: Comparison of theoretical heat flux – Equation (38) vs. measured**

The experimental results by Wilson et al (2002) showed reasonable variation between measured element temperature using thermocouples connected to the element, and an optical pyrometer, which used a wider sampling area than the thermocouples. This showed that there was variation between points around the cone element for surface temperature, and consequently a variation in received flux against the expected value given by Equation (38). Visually, it can be seen from the colour when operating the

cone that there is some variation in the element temperature, with the ends of the cone element in the frustum in particular being cooler than the general element temperature. The model is also based on a smooth cone surface as it does not take into account the effect of the spiral element or re-radiation from the supporting elements or the sample holder and takes no account of the element coils.

The view factor calculation is not required for the RIFT, which can be set up empirically, based on flux measurements, so no further work was be done in this area.

# 7 Literature on the LIFT, RIFT and lateral flame spread

Unlike the cone calorimeter, where a significant number of papers have been published, little has been published on the ASTM 1321 LIFT apparatus. This is largely due to the more limited nature of the test when compared to the cone calorimeter. The cone calorimeter can be used for product comparisons, modelling compartment fire and upholstered furniture behaviour and other legislative tests (Babrauskas, 1992). In comparison, the LIFT is purely a measure of flame spread, and some ignition properties. Some work has been done to model the LIFT using only cone calorimeter data, with mixed success.

The publications given here are most specifically dealing with the LIFT and RIFT. A summary of more general ignition and flame spread research is given by Huynh (2003), Ngu (2002) and Babrauskas (2003).

## *7.1 LIFT literature*

### 7.1.1 Quintiere, J. A simplified theory for generalizing the results from a radiant panel rate of flame spread apparatus. 1981

The basis of the mathematical model for flame spread, which forms the basis of the ASTM E 1321 LIFT and hence the RIFT was initially developed by Quintiere (1981). Although based on the ASTM E 1317 / IMO maritime finishes test apparatus, the derivation makes it generally applicable to any case of opposed flow flame spread under radiant heating, and the resulting equation is that of Equation (28).

The requirement for preheating the material in order to aid data reduction is given, but the method of defining the preheating time is given as “trial and error” by observing the results of the flame spread correlation for linearity.

### 7.1.2 Quintiere, J. Harkleroad, M, Walton D. Measurement of material flame spread properties. 1983

The work by Quintiere, Harkleroad and Walton in further developing and applying the theories developed by Quintiere (1981) led to the current ASTM LIFT apparatus and procedure. The theory was further developed to be able to calculate the preheating

time required using the ignition parameter. The flame spread theory was further developed and applied to particle board as an example material

The apparatus was further modified to give more consistent results. Amongst these were the location of the pilot flame and the addition of a flange on the top of the sample holder to improve the consistency of the ignition time and reduce the effect of the pilot flame on the material.

### 7.1.3 Quintiere, J. Harkleroad, M. New concepts for Measuring flame Spread Properties, 1984

The theories developed earlier by Quintiere ET al (1981, 1983) were applied in a series of experiments to obtain material properties for a wide range of materials. This work formed the basis of the ASTM E 1321 standard. Much of the published material properties in the literature (for example, in Quintiere 2000) come from the results published in this paper.

### 7.1.4 Fowell, A. Interlaboratory test program on ASTM E 1321: Standard test method for measuring material ignition and flame spread properties. Second edition, November 1994

As part of an ongoing research program into the repeatability of various ASTM test methods, a round robin of tests of 6 materials, held in 4 laboratories was conducted by the ASTM, although the results for one material (particle board composite) were withdrawn as one laboratory had received the wrong material. The materials tested were:

- Douglas Fire plywood
- Fire retardant treated Douglas Fir plywood
- Composite panel
- Type X gypsum wall board
- Rigid polystyrene foam
- Rigid polyurethane foam

No detail of the raw experimental data is given, however some statistical analysis was conducted to give some indication of the variability inherent in the ASTM E 1321 test method. Of interest to this research are the results for the flame spread parameter $\Phi$,

minimum ignition flux and the other properties, which gave an indication of the acceptable range when comparing with other published results in the literature. The results showed large variations in the results for the flame spread parameter, where the highest value was over 2 times the lowest value. The other results showed large variation, but on a smaller scale.

### 7.1.5 Dietenberger, M. Experimental and analytical protocol for ignitability of common materials. 1995

Dietenberger conducted a number of tests on wood products for the US Forest Service involving the LIFT and cone calorimeter, with the results published in several papers in 1995 and 1996.

This report covers a new protocol for calibration of the LIFT, and recommendations for improving the calibration when aligning the burner to match the required flux profile. The use of at high irradiance level was also recommended, to reduce the error due to the time taken to insert the sample into place. The main result was the development of a function for the actual heat transfer coefficient along the material, given in Equation (39).

$$h = (13.9 - 0.0138x)(q''_{e,50mm}) \text{ kW/m}^2\text{K}, \quad \textbf{(39)}$$

where $x$ is the distance along the sample from the hot end, in metres.

The measured convection coefficient component of the heat transfer coefficient is varies along the sample, and the heat transfer coefficient is significantly higher than the standard value of 0.015kW/m$^2$K specified in the ASTM E 1321 standard at points closer than 650mm from the hot end of the sample, and it varies significantly with the panel radiant flux. As a result, using equation (6) and the standard heat transfer coefficient value given in the ASTM E 1321 LIFT standard, gives a higher ignition temperature than experimentally measured values. Using the corrected heat transfer coefficient calculated from equation (39) gave ignition temperatures around 70°C less than predicted for the same materials using the ASTM standard value.

A theory of ignition was developed that interpolated the results between thermally thick and thermally thin materials, to allow for the effect of thermal penetration on the sample.

### 7.1.6 Dietenberger, M. Ignitability of siding materials using a modified protocol for LIFT apparatus. 1995

The effect of moisture content, apparatus and thickness of the test samples on ignitability were tested for typical US external cladding materials - Cedar, Redwood, Southern Pine, plywood, hardboard and vinyl faced polystyrene foam. A method is proposed to take into account the effect of moisture content on the ignitability of the material, in order to predict the ignition time and thermal properties, given results at an oven dried moisture level.

### 7.1.7 Dietenberger, M. Ignitability analysis using the LIFT apparatus and cone calorimeter. 1995

The ignition theory for finitely thermally thick materials with radiant heating, convective cooling and an insulated back face was further developed to give a better correlation result. It is a function of the Biot (Bi) and Fourier (Fo) numbers for the material under the test conditions:

$$\frac{\dot{q}''_e}{\dot{q}''_{ig}} = \frac{1}{T_s} = 1 + \frac{1}{(F''_{thick} + F''_{thin})^{1/n}} \quad \textbf{(40)}$$

where

$$\dot{q}''_{ig} = h_{ig}(T_{ig} - T_\infty)/\varepsilon \quad \textbf{(41)}$$

$$n = (2.68 + 0.4Bi)/(1 + Bi) \quad \textbf{(42)}$$

$$F''_{thick} = \left(\frac{4}{\pi} Bi^2 Fo\right)^{\frac{1}{2}} \quad \textbf{(43)}$$

$$F''_{thin} = \exp\left(\frac{BiFo}{1 + 0.254Bi}\right) - 1 \quad \textbf{(44)}$$

The advantage of this theory is that the assumption of thermal thickness is not required, and the thermal thickness can change through the test at different irradiances and still give satisfactory results.
The heat transfer coefficient equation was also developed for the cone calorimeter.

### 7.1.8 Jianmen, Q. Prediction of flame spread test results using the test data from the cone calorimeter. 1990

Jianmen (1990) attempted to model the flame spread on materials using a view factor calculation and material properties derived from cone calorimeter tests. Using the results from the ISO standards LIFT round robin test, the results looked to give a reasonable match, however later work by Goransson (1991) showed poor results in tests of varying materials. The materials tested were chosen to include as wide a range of properties as possible, and the materials were insulating fibreboard, particle board, PVC carpet on gypsum board and transparent PMMA

### 7.1.9 Goransson U. Using the cone calorimeter to predict flame spread, 1991

Goransson (1991) conducted tests using the LIFT to attempt to verify the flame spread model developed by Jianmen (1990) and had little success. The problems identified included the assumption in the model that the heat transfer from the flame to the unburnt material was via radiation, when gas phase conduction was the main method, and that the choice of values taken from the cone data does not necessarily represent the flame spread accurately.

### 7.1.10 Persson G. Predicting lateral flame spread with cone calorimeter, 1993

Following the work by Jianmen (1990) and Goransson (1991), Perrson (1993) used a numerical solution to an integral model of surface flame spread, using the experimental data by Goransson. Most of the data required for the model could be obtained from experimental results in the cone calorimeter. These included:

- Heat flux $\dot{q}_e''$ along the sample
- Preheating time $t^*$

- Material thickness
- Thermal inertia $k\rho c$
- Thermal conductivity of the material $k$
- Ignition temperature $T_{ig}$
- Flame heat flux parameters called $\dot{q}''_{f0}$ and $k_f$

The flame heat flux parameters are used to define a decaying heat flux from the flame front on the unburnt material, where the heat flux from the flame is given in equation (45).

$$q''_f = q''_{f0} \exp(-k_f (x - x_f) \quad \textbf{(45)}$$

A recognised shortcoming was that the flame heat flux parameters are difficult to define experimentally due to the small scale of the heat affected area and a wide combination of $q''_{f0}$ and $k_f$ will give similar results. This is explored further by Delichatsios (1999).

The results showed some success in the materials listed for the ASTM E 1317 / IMO marine finishes test, but performed poorly in the LIFT test. While the equipment is similar, apart from the differences in the pilot flame location, the IMO test involves a fixed peak heat flux of 50kW/m$^2$ and no preheating time before ignition. The preheating was identified as the main reason why the theory did not perform well against the experimental results. The effect of preheating on the material properties was recognised by Babrauskas and Wetterlund (1999).

#### 7.1.11 Babrauskas, V. Wetterlund, I. Comparative data from LIFT and cone calorimeter tests for 6 materials, including flame flux measurements. 1999

A key part of developing the models of opposed flow flame spread is the heat flux from the flame to the surface of the material. Following an earlier literature review into flame fluxes in opposed flow flame spread (Babrauskas, 1995) where little information had been found, particularly for the LIFT, experiments were conducted at

SP in Sweden on 6 materials with both the LIFT and cone calorimeter. These materials included

- particle board,
- fire retardant polyurethane foam,
- black PMMA,
- insulating fibreboard,
- cotton fabric with a Kevlar liner over polyurethane foam,
- acrylic pile fabric over polyurethane foam.

In addition to measuring the heat flux from the passing flame front to the material, the report covers the requirements of the ASTM standard, and discusses the problems with the standard regarding clarity and definition of some of the terms, and the effect of preheating on the material. Some tests were done without preheating and the data is included, but no calculations were done or conclusions drawn, as it is outside the Standard requirements. The effect of preheating on the material properties was found to affect some of the materials, in particular the foams.

It was found that the flame flux is essentially constant between the materials tested, and hence this should not be a major variant in flame spread modelling.

### 7.1.12 Nisted, T. Flame spread experiments in bench scale; project 5 of the EUREFIC research program. 1991

Nisted conducted a series of LIFT tests, as part of the wider "European Reaction to Fire Classification" research program, where the 11 materials covered a range of material properties. The report covered only the LIFT tests, the experimental procedure and results obtained.

Of particular interest to this report were the tests for "ordinary" plywood. The raw test data is included by Nisted, which was used to confirm the calculations used in the post experimental processing in this report.

## *7.2 RIFT literature*

### 7.2.1 Azhakesan, A. Shields, T. Silcock, G. Ignition and opposed flow flame spread using a reduced scale attachment to the cone calorimeter. 1998

The paper by Azhakesan et al in 1998 was the first publication on the RIFT method, and all the resulting work stems from it. The method is described, and four materials are tested – fibreboard, hardboard, plywood and melamine faced particle board. The results are compared with published data for the LIFT and the BS476 part 6 Surface spread of flame test, rather than testing the same material in these tests. The conclusion was that the RIFT produced similar results to the tests and could give a comparative result to the BS476 part 6 test, with the flame spread parameter slightly higher than the LIFT results produced.

### 7.2.2 Azhakesan, A. Shields, T. Silcock, G. Combustibility parameters for enclosure lining materials obtained during surface flame spread using reduced scale ignition and flame spread technique. 1998

This publication is a continuation of the previous paper, and expands the use of the RIFT. Heat release rate and mass loss rate data was gathered during the flame spread test in the RIFT, allowing the calculation of heat of gasification and the heat release per unit area burnt to be calculated in addition to the opposed flow flame spread properties calculated in the conventional test.

### 7.2.3 Huynh, VCM. Flame spread measurements of New Zealand timber using an adaptation of the cone calorimeter apparatus. 2003

Some earlier work by Pease (2000) at the University of Newcastle in Australia to replicate the work of the work of Azhakesan et al led to Huynh (2003) using the University of Newcastle apparatus to attempt to derive some properties for New Zealand timber using the RIFT. Huynh used ignition data, which forms part of the flame spread analysis, from Ngu (2002) which used the ISO 5657-1987 ignitability apparatus. Both the work by Pease and Huynh suffered from a shortcoming in the test

apparatus, where the sample was exposed to only half the available element area, and consequently the results were inconclusive. A summary of this research is also given by Spearpoint, et al 2005.

# 8 Material test results for manufactured boards

This chapter describes the ignition and flame spread results obtained in the tests on manufactured boards with both the LIFT and the RIFT.

Ignition tests for each material were conducted at different heat flux in the ISO 5657 apparatus, the LIFT and the RIFT to obtain the material properties required for the flame spread tests. The flame spread tests were conducted in the RIFT and LIFT. A minimum of 4 samples of each material was tested in the RIFT, with 6 samples if allowed by the available material. Three samples of each material were tested for flame spread in the LIFT.

Some additional flame spread and RIFT ignition tests were conducted on different thickness materials of the same nominal type, to gauge an indication that the effect of material thickness may have on the results.

As particle board is a common material used for research in the literature, two brands of particle board were tested in the RIFT to show the variation within a material and hence some indication of the error when comparing the experimental results to those published in the literature.

The effect of preheating the sample on flame spread was investigated by conducting tests in the RIFT with full preheating, given by the ISO 5657 ignition tests, and a low preheating period of a few seconds.

The results for manufactured board were generally more consistent with less variation between tests on the same material than those for natural timbers, as expected from their more consistent composition. The results are summarised in Appendix 3 along with the ignition data, and the raw data from the flame spread tests is in Appendix 4

## *8.1 Medium density fibreboard*

The MDF used in these tests was 18mm “Customwood” brand by Carter Holt Harvey and six samples of 18mm “Customwood” MDF were tested in the RIFT with a low preheat and a full preheat time, and the same material was used in the LIFT to compare results. The ignition results in the LIFT, RIFT and ISO 5657 apparatus used samples of the 18mm MDF. The extent of flame spread along the sample is shown in

Figure 48. Some flame spread tests were conducted on 9mm MDF to look at the effect of thickness on the flame spread rate and variation.

### 8.1.1 Ignition of MDF

MDF showed very consistent ignition and flame spread properties when tested, with little variation between runs. The time to ignition for MDF in the LIFT, RIFT and ISO 5657 tests is shown in Figure 43.

The results for ignition in the ISO 5657 ignition apparatus are compared with those obtained by Ngu (2002), who also used the ISO 5657 ignition apparatus to test various New Zealand timbers, shown in Figure 44. The ignition results in these tests are within the error limits of the tests by Ngu, showing the material is very consistent.

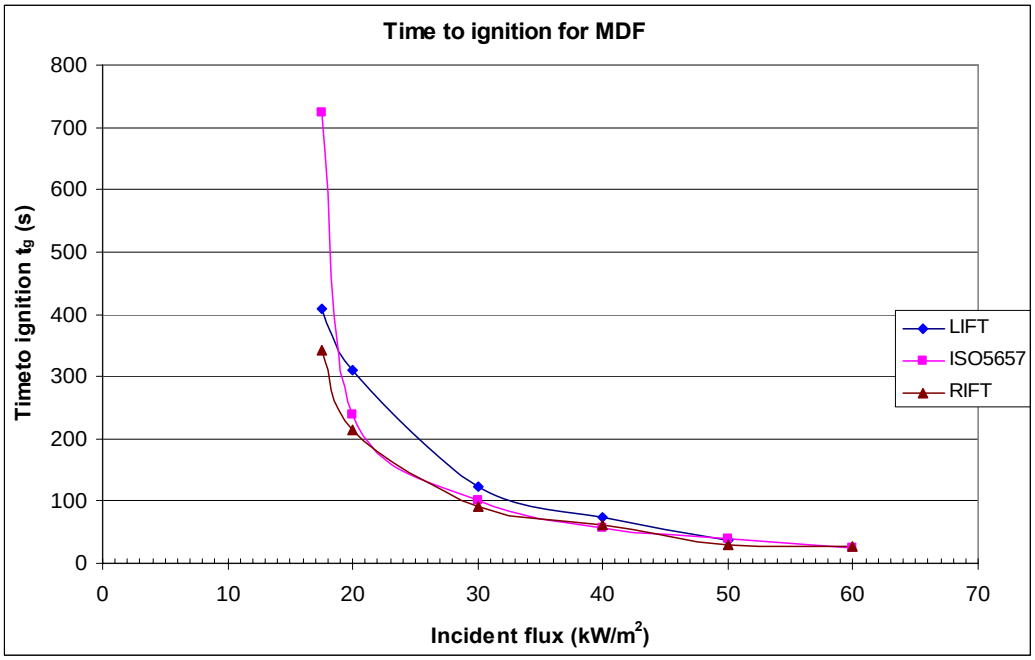



**Figure 43: Time to ignition for MDF**

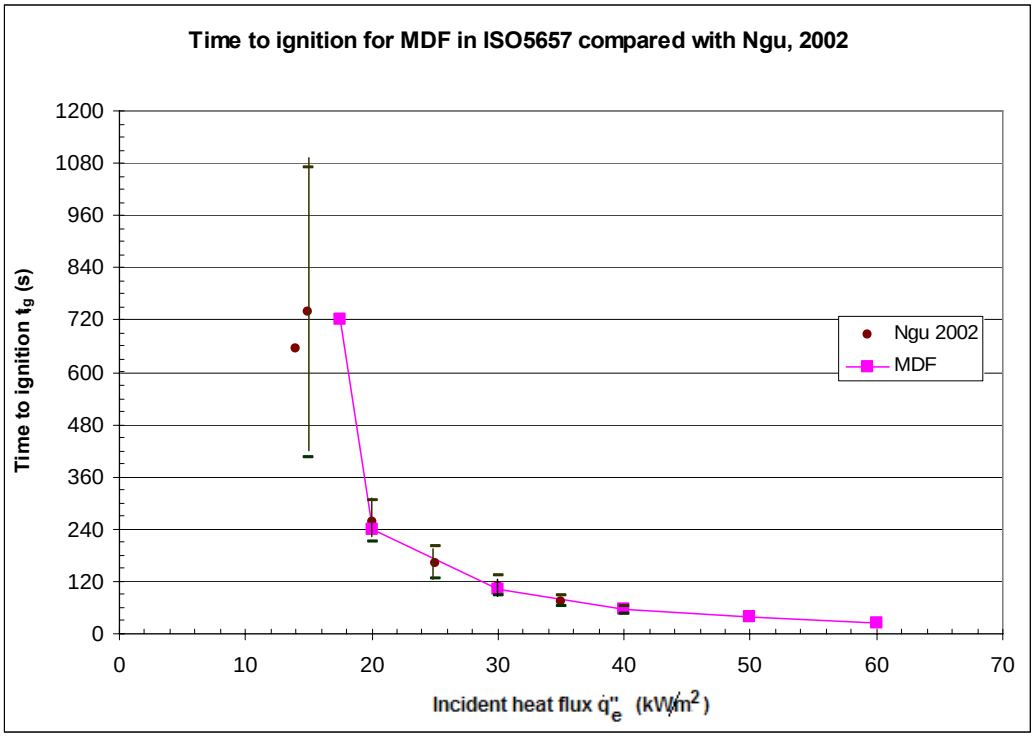



**Figure 44: Comparison of time to ignition of MDF in ISO 5657 apparatus with Ngu (2002)**

Plotting the incident heat flux ($\dot{q}''_e$) vs. $1/\sqrt{(t_{ig})}$, shown in Figure 45, gives the critical heat flux ($\dot{q}''_{crit}$) from the intercept with the x-axis.

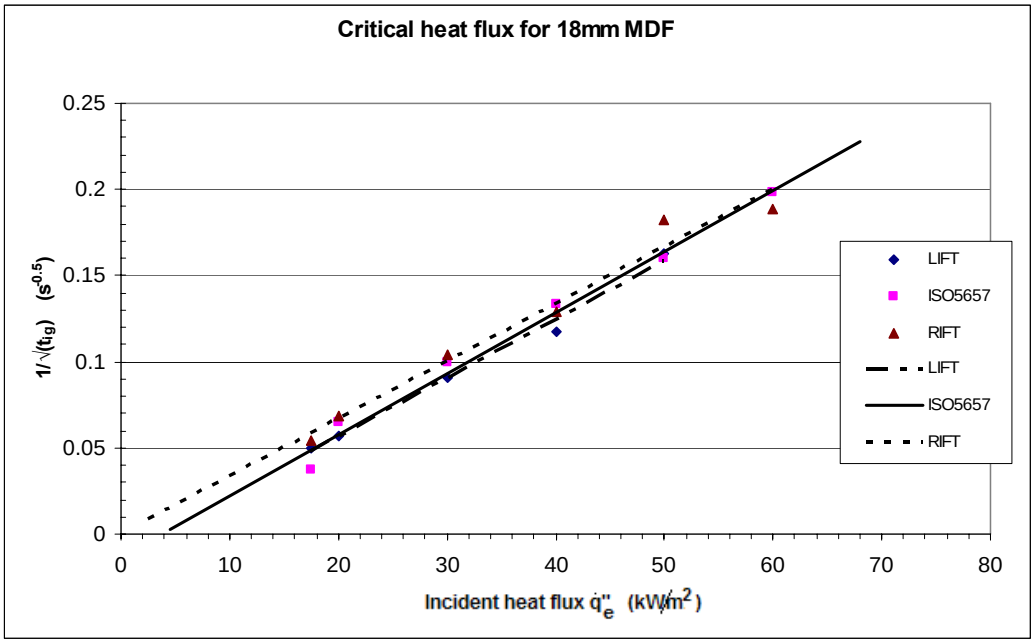



**Figure 45: Critical flux for 18mm MDF**

Using the protocol from ASTM E 1321-97a, the ignition parameter is calculated (Figure 46) by plotting $(\dot{q}''_{ig,\min})/(\dot{q}''_e)$ vs. $\sqrt{(t_{ig})}$. The intercept of a best fit line with $(\dot{q}''_{ig,\min})/(\dot{q}''_e) = 1$ gives the square root of the preheating time $\sqrt{t^*}$ for the time for the sample to reach thermal equilibrium ($t^*$). The slope is the ignition parameter "*b*".

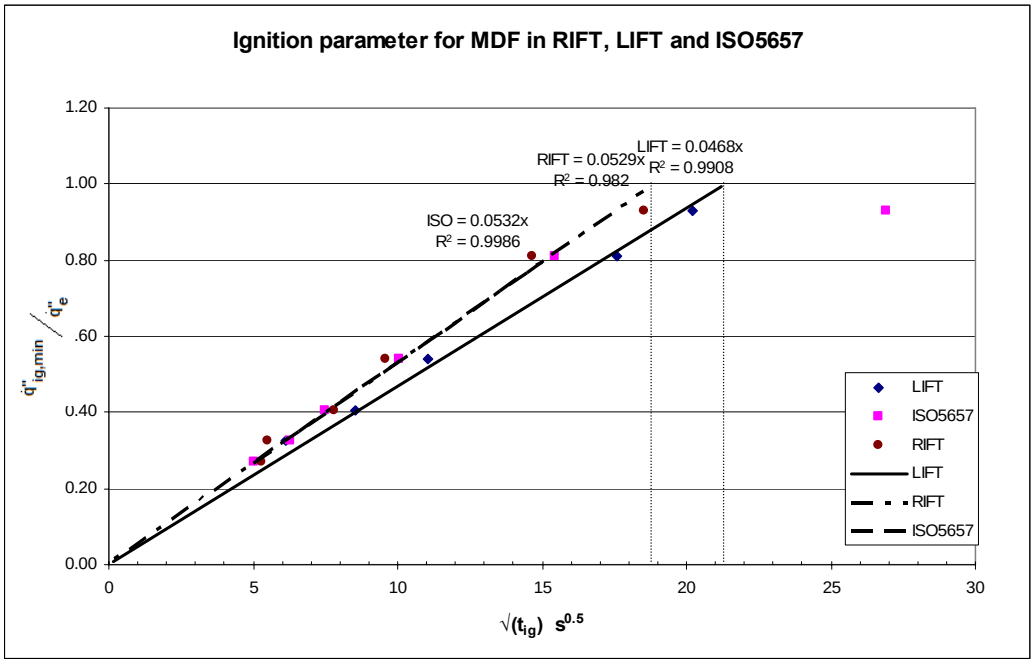



**Figure 46: Ignition parameters from ASTM e1321-97a for MDF**

### 8.1.2 Flame spread of MDF

The LIFT was set to a $\dot{q}''_{50mm}$ heat flux of 24kW/m$^2$ and the profile measured using the flux gauge and template, with the resulting profile shown in Figure 47. The RIFT was setup as outlined in section 6.2.

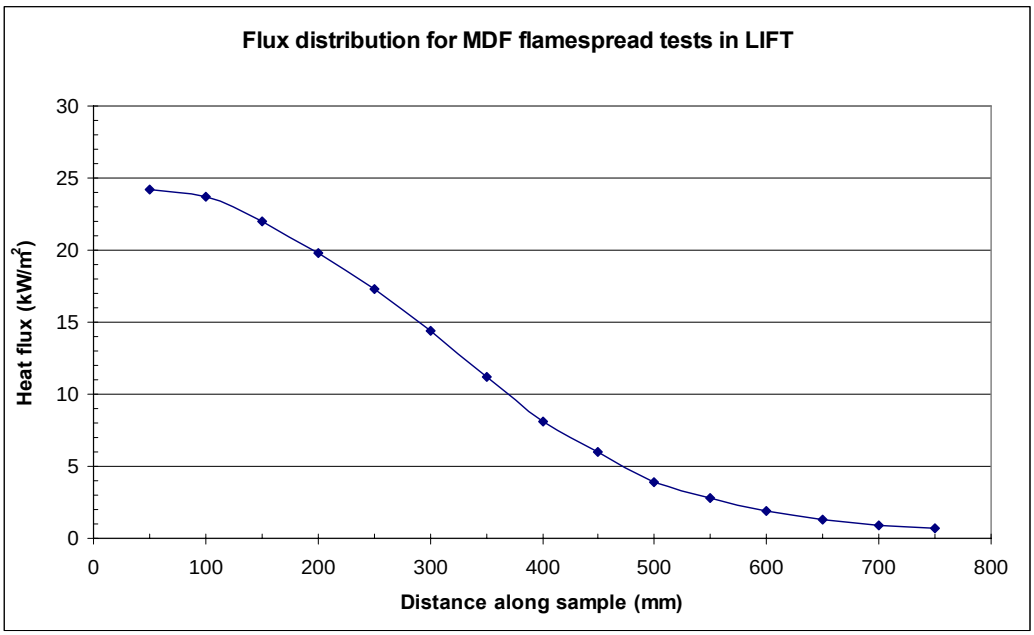



**Figure 47: LIFT heat flux profile for MDF flame spread test.**

*The effect of preheating*

MDF was compared in the RIFT with and without preheating the material fully to thermal equilibrium prior to ignition. The comparison of distance along the sample against time from ignition is shown in Figure 48, where the unpreheated sample has a lower flame spread rate, and the extent of flame spread is less. The lesser extent of flame spread means that the value for $\dot{q}''_s$ – the minimum heat flux for flame spread - is higher for the unpreheated sample. It shows that the flame front progressed faster than the material could heat to the minimum ignition temperature, and hence the flame self extinguished before the maximum flame spread distance could be achieved.

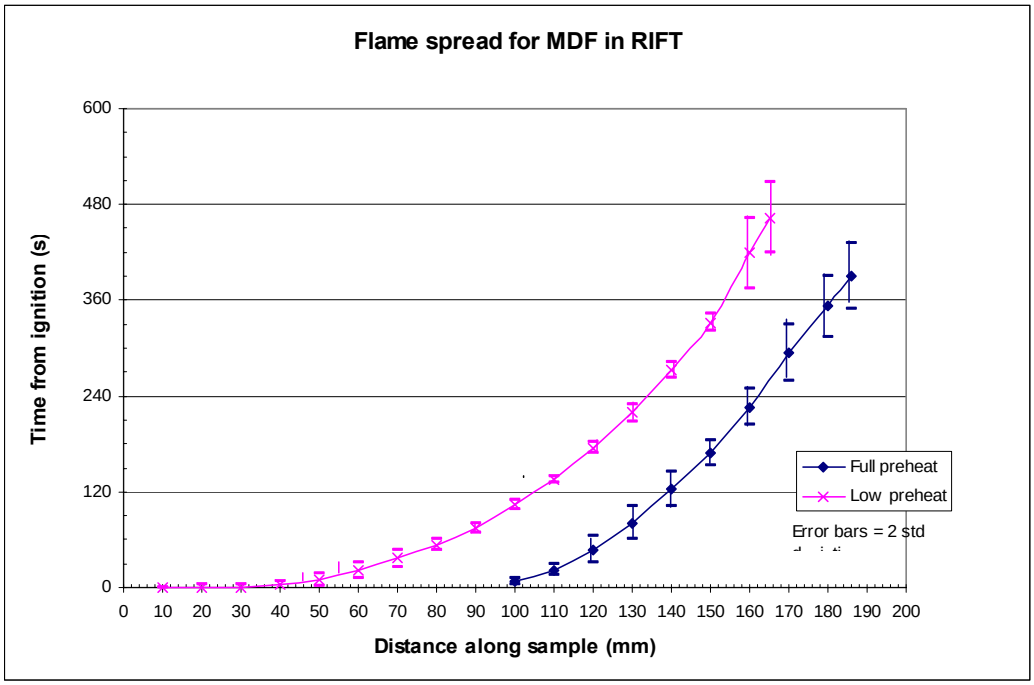



**Figure 48: Flame spread of 18mm MDF in RIFT**

The effect of preheating can be seen from Figure 49 and Figure 50, where the slope of the data fit line of the flame spread correlation decreases until the material reaches equilibrium, reflecting the slower flame spread rate of the unpreheated material, due to a lower surface temperature. Tests with varying preheating times were not conducted in the LIFT.

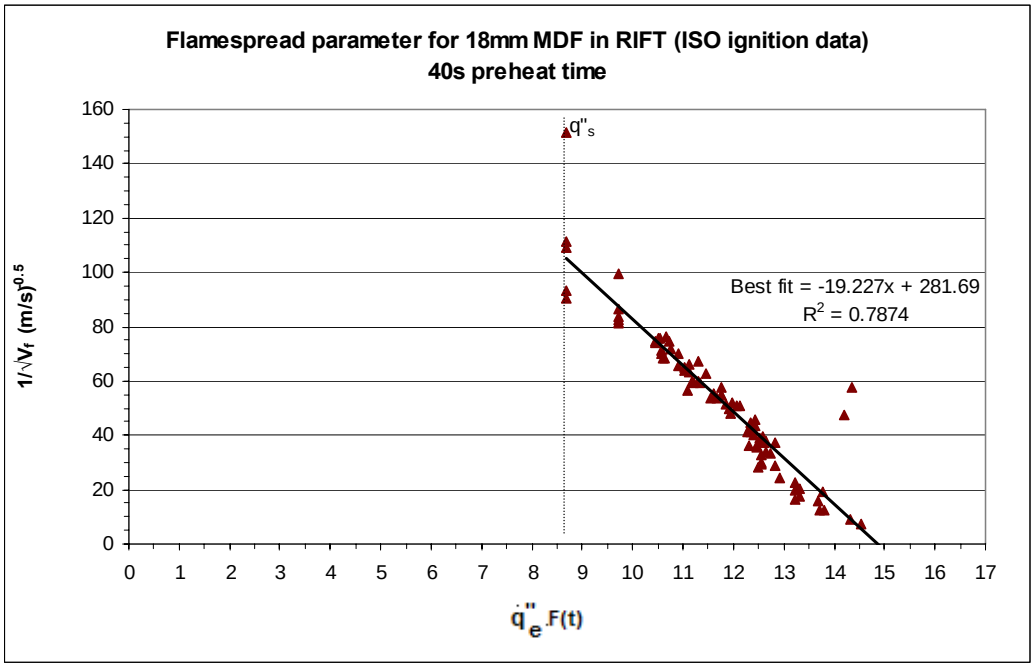



**Figure 49: Flame spread parameter for 18mm MDF in RIFT using ISO ignition data and 40s preheat**

*Comparison of MDF in RIFT and LIFT*

The flame spread correlations for the LIFT and RIFT are compared in Figure 50. The RIFT and LIFT produce similar results for both the slope of the data fit line, which leads to the flame spread parameter, and for the values of the minimum flux for flame spread. The RIFT gives a higher value for the minimum ignition flux from the correlation.

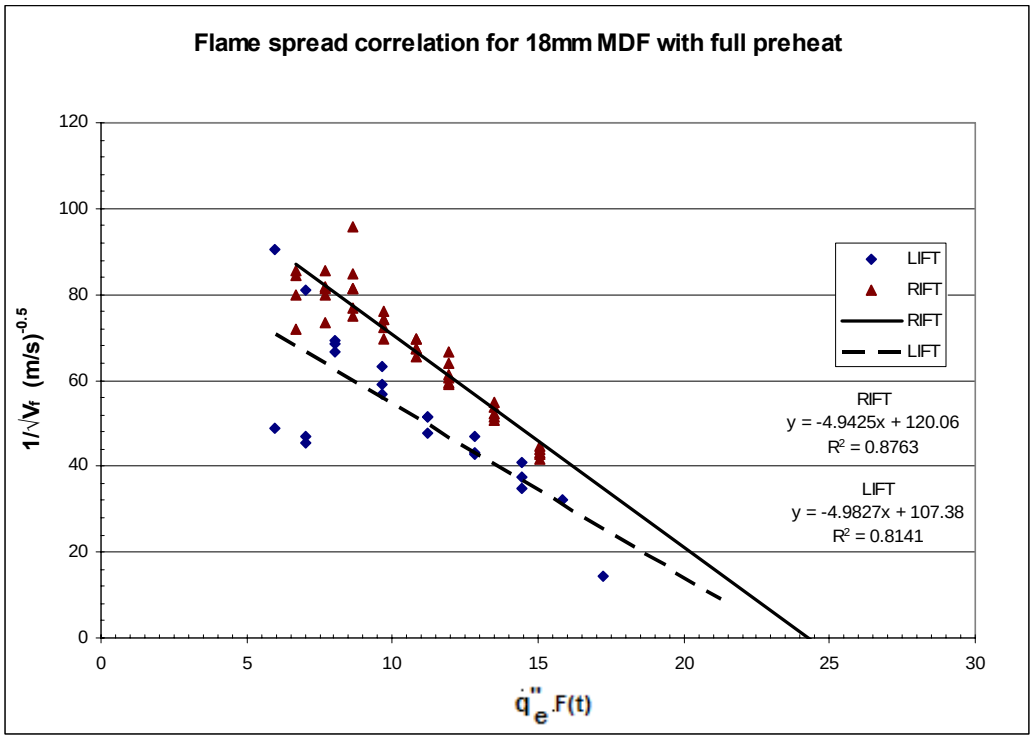



**Figure 50: Flame spread correlation for 18mm MDF in RIFT and LIFT**

*The effect of sample thickness on flame spread*

As a check on the effect of sample thickness on the flame spread, the flame spread for 6 pieces each of 9mm and 18mm MDF is compared in the RIFT with no preheating, shown in Figure 51. This shows that for this material, the two thicknesses have similar flame spread results, with the 18mm MDF having a slightly slower flame spread rate than the 9mm MDF.

This is expected to be due to thermal penetration of the thinner material, which is backed by a lightweight insulating board, allowing the material to reach a higher temperature at a given time than the thinner material. The 9mm MDF also had a far higher variation between the runs than the thicker material.

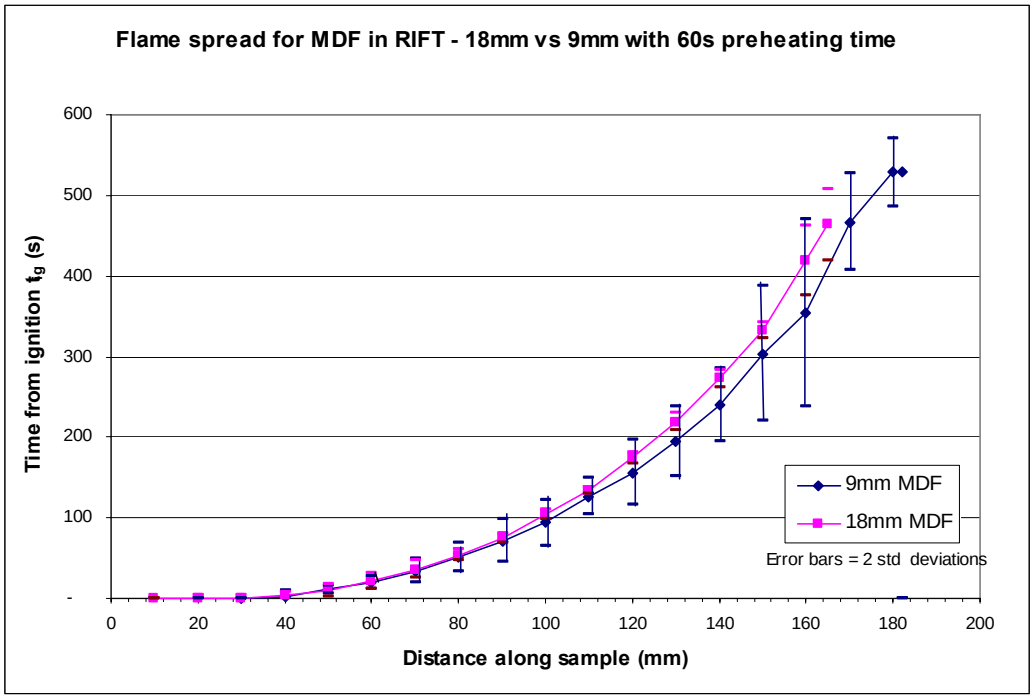



**Figure 51: Flame spread for 9mm and 18mm MDF in RIFT with low (60s) preheating time**

## *8.2 Particle Board (Chipboard)*

Samples of 20mm "Pynefloor" flooring grade particle board were tested in the ISO 5657 ignition testing apparatus, the RIFT and the LIFT. In addition, a different brand (20mm "Superflake"), of nominally the same material, was also tested in the RIFT and ISO 5657 apparatus to compare the time to ignition and the flame spread rate in the RIFT, and hence the variation between materials of the same nominal type.

The results are summarised in Appendix 3

### 8.2.1 Ignition of particle board

As particle board is a commonly used material in the research literature, the two brands of particle board were compared for ignition, to see if there was significant variation between two samples of the same nominal material, and hence gauge the expected variation with published results. The ignition results in the ISO 5657 ignition apparatus is shown in Figure 52 and Figure 53

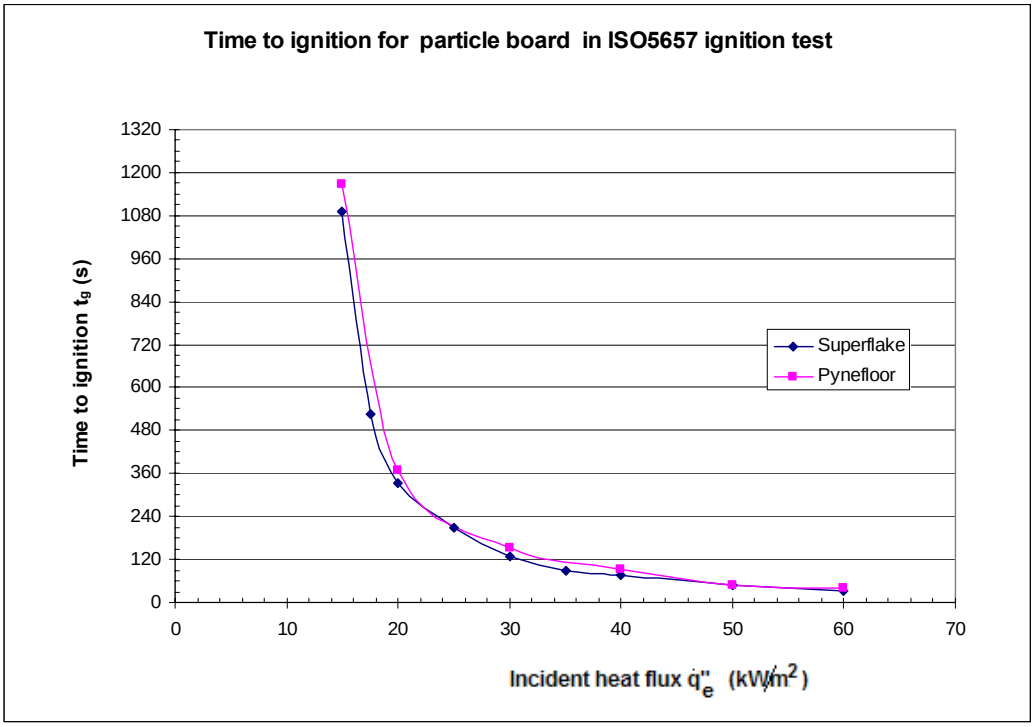



**Figure 52: Ignition time for 2 brands of particle board in ISO 5657 apparatus.**

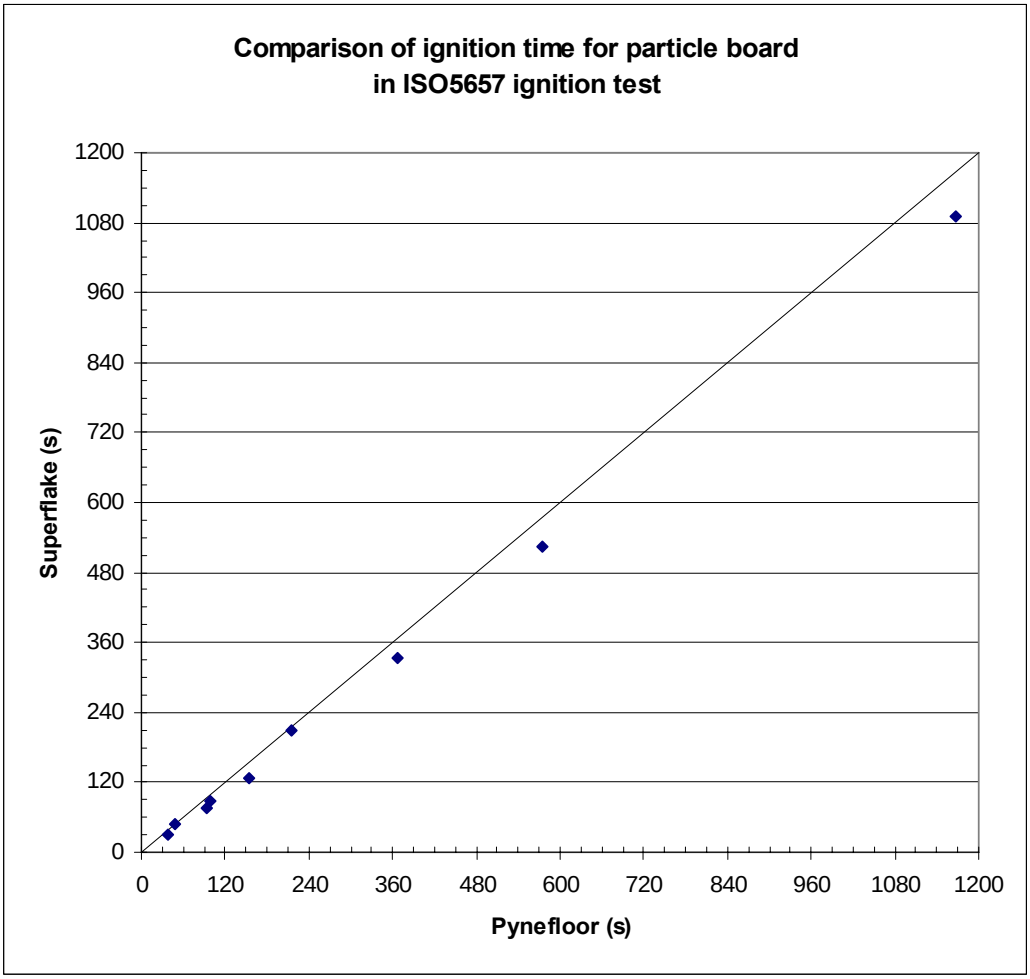



**Figure 53: Comparison of ignition times for particle board**

There is a difference between the 2 brands, but it is small and appears to be approximately in proportion to the product density., where the higher density material (Pynefloor) has a longer time to ignition at any given heat flux level.

The results of the ignition tests for Pynefloor are shown in Figure 54, where the minimum flux for ignition ($\dot{q}''_{ig,\min}$) is 13.75kW/m$^2$ for the ISO 5657 ignition tests. The LIFT and RIFT gave higher values for the minimum ignition flux, in line with the expected findings. The results for Superflake (Figure 55) are similar.

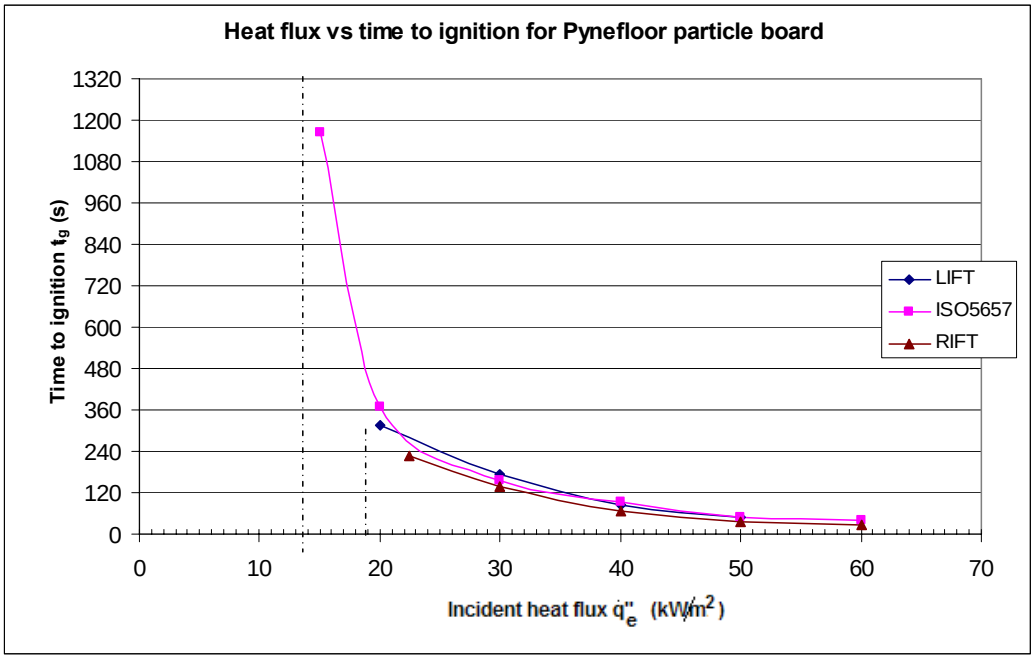



**Figure 54: Time to ignition for Pynefloor particle board**

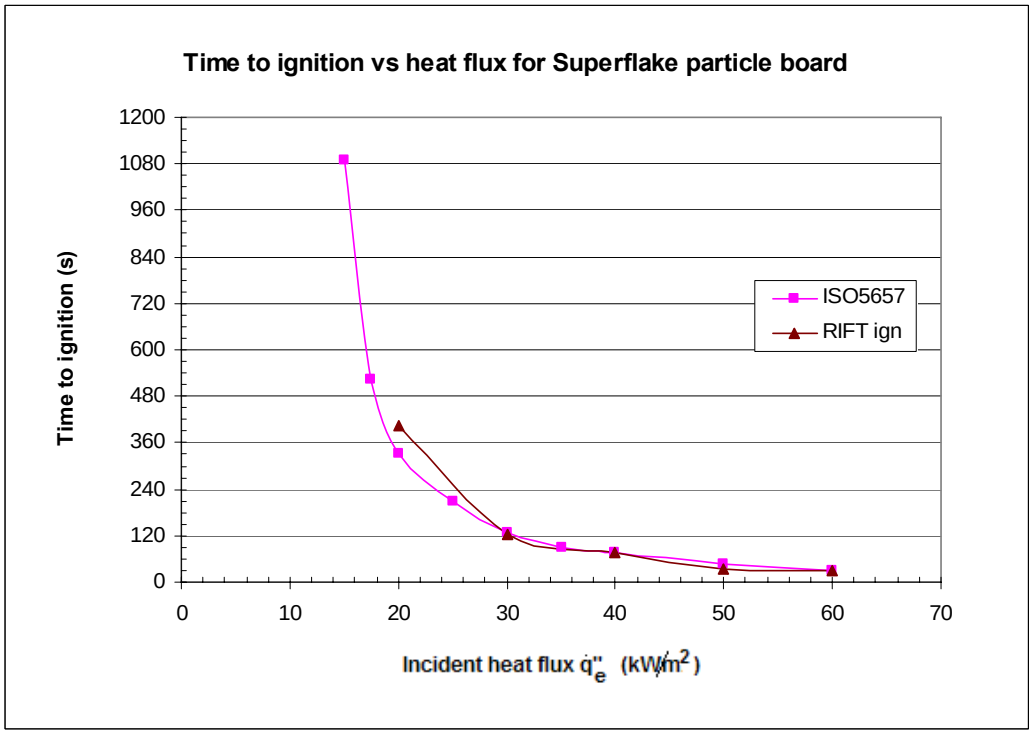



**Figure 55: Time to ignition for Superflake particle board**

The ignition parameters for Pynefloor from the different tests are given in Figure 56. The effect of the different ignition tests on the ignition parameter value "*b*", which is the slope of the best fit line can be seen, as well as the preheating time $t^*$, where $(t^*)^{1/2}$ is the intercept where the ignition parameter line crosses $\dot{q}''_e / \dot{q}''_{ig,\min} = 1$ .

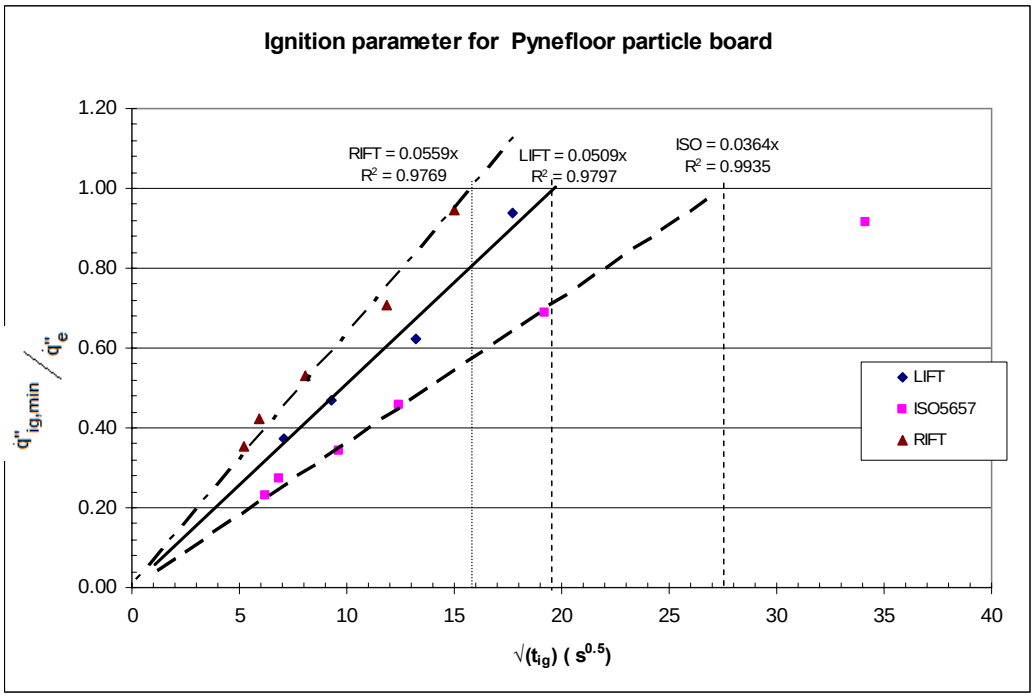



**Figure 56: Ignition parameter for Pynefloor particle board**

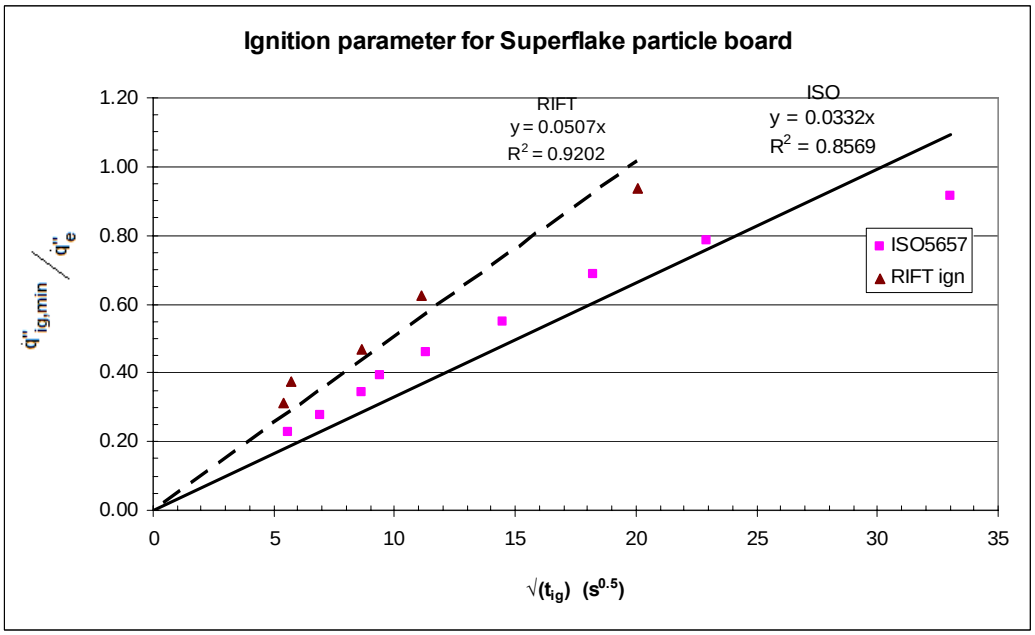



**Figure 57: Ignition parameter for Superflake particle board**

The critical ignition flux for the two brands of particle board (Figure 58 for Pynefloor, and Figure 59 for Superflake) gives very similar results.

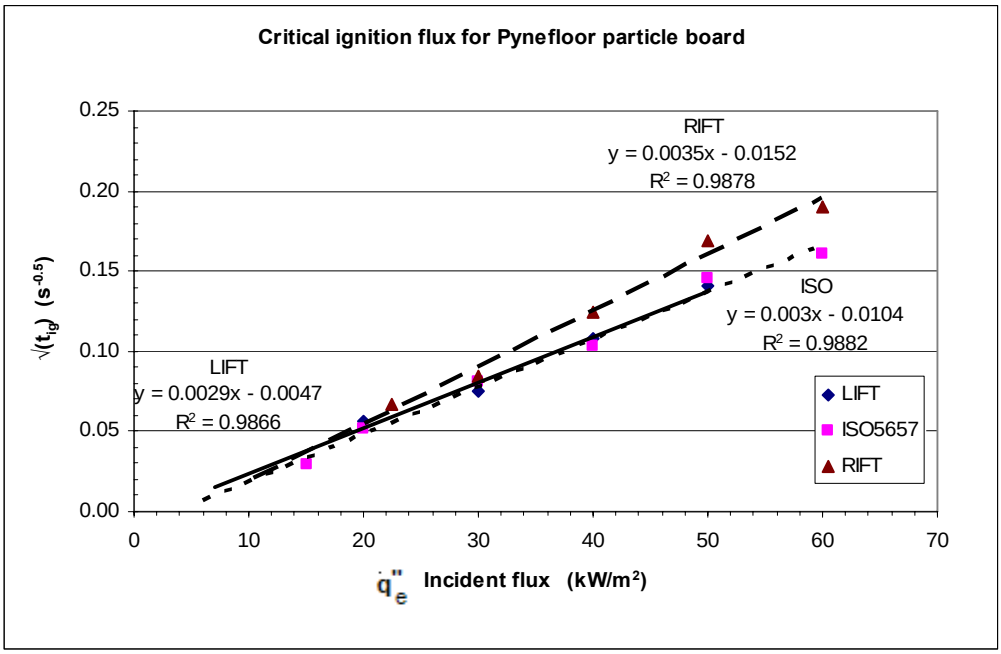



**Figure 58: Critical ignition flux for Pynefloor particle board**

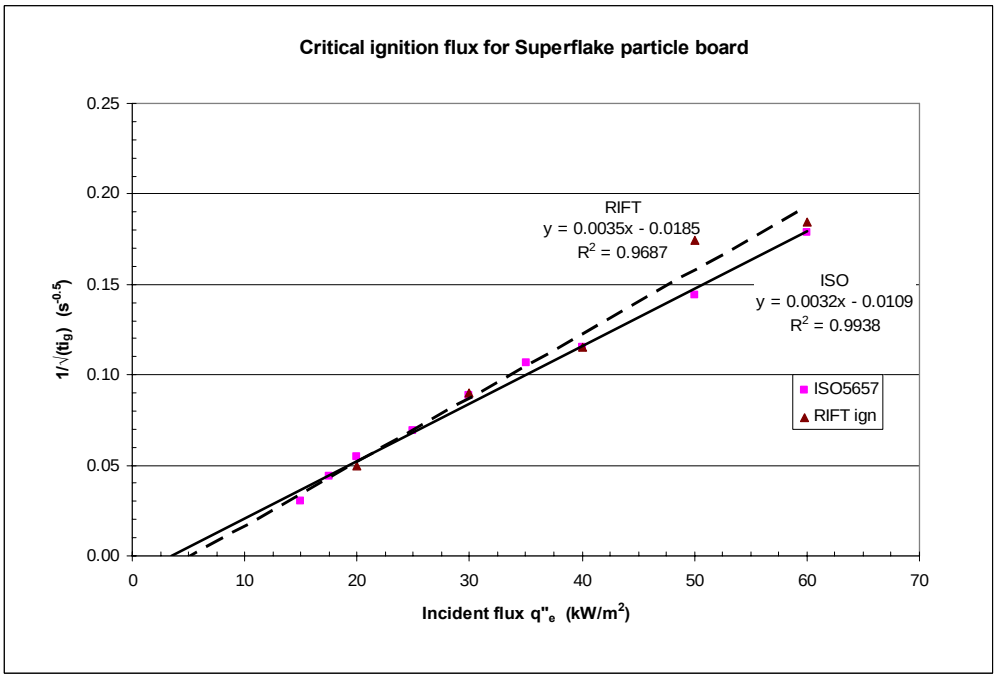



**Figure 59: Critical ignition flux for Superflake particle board**

As a comparison between Janssen's ignition theory and that of Quintiere, the critical ignition flux $q''_{crit}$ is shown in Figure 58 and Figure 60. Typically, Janssen's correlation gives a slightly higher value for the critical ignition flux; due to the steeper slope of the data fit line. In this case the values for the Quintiere model and the Janssen's correlation are 5.5 and 6 kW/m$^2$ respectively for Pynefloor particle board. The Quintiere model give 3.4kW/m$^2$ for Superflake, against 5.8kW/m$^2$ for the Janssen's' model for the same material.

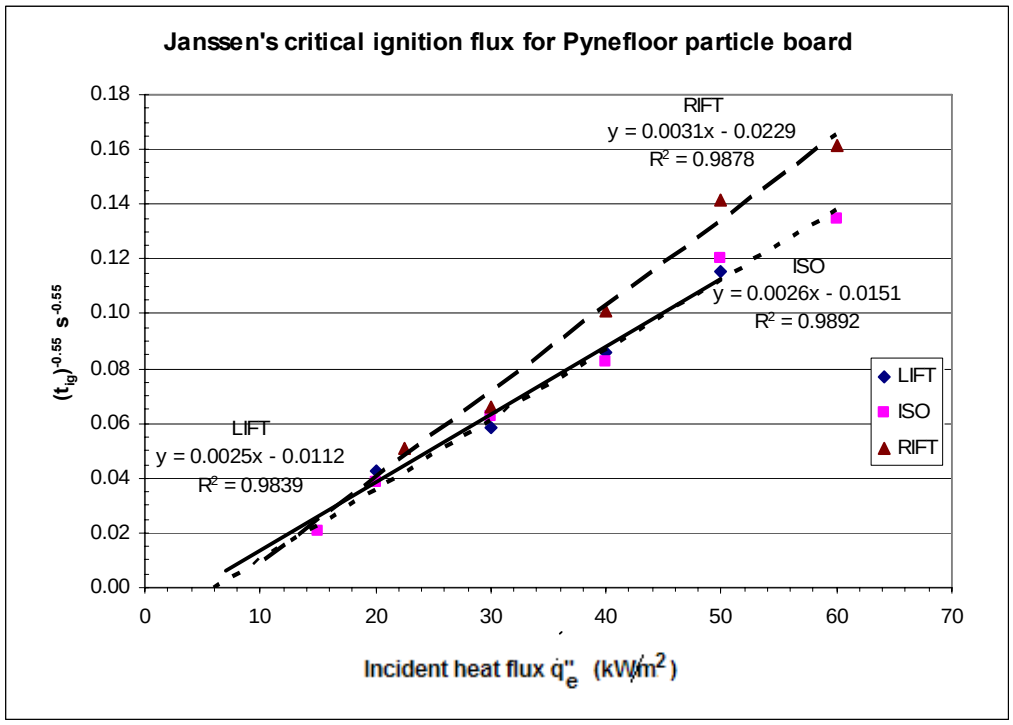



**Figure 60: Janssen's critical ignition flux for Pynefloor particle board**

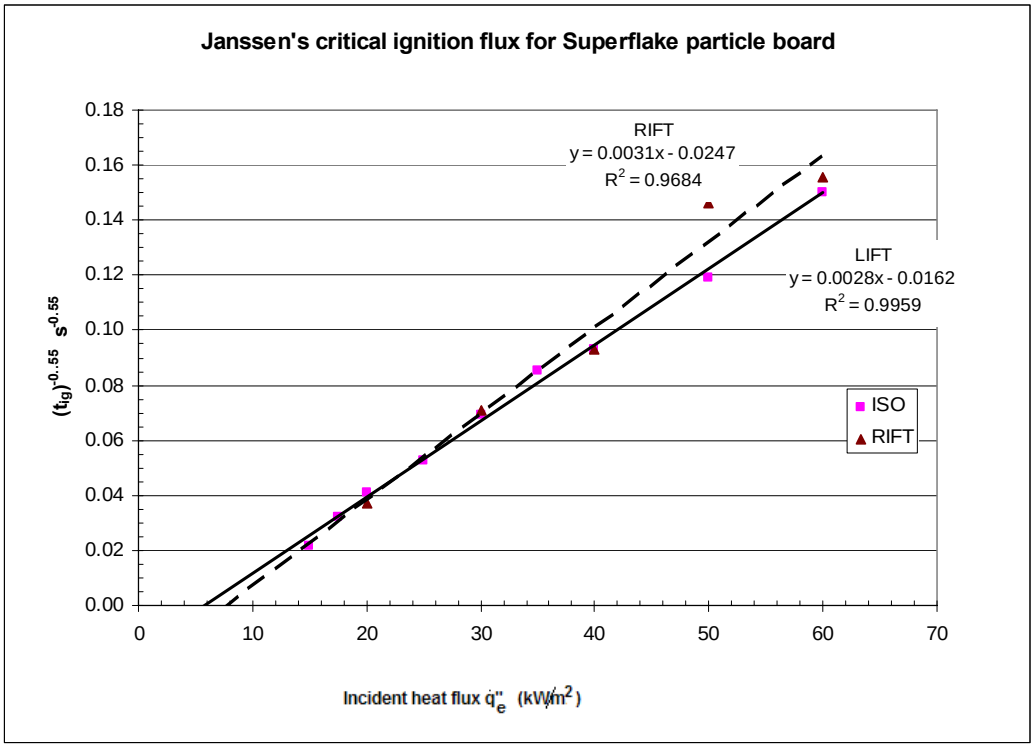



**Figure 61: Janssen's critical ignition flux for Superflake particle board**

### 8.2.2 Flame spread for particle board

*Flame spread in RIFT*

A preheat time of 80 seconds was used for the low preheat tests. The $t^*$ time of 755 seconds from the ISO 5657 ignition was used for the full preheat time for the RIFT tests, and the $t^*$ time of 386 seconds from the LIFT ignition test was used for the LIFT flame spread tests.

A comparison of the flame spread between the 2 brands of particle board in the RIFT shows a minor difference in the flame spread rate (Figure 62 and Figure 63), which affects the final flame spread properties. This reflects the ignition test results, where the Superflake board had a shorter time to ignition at for any given heat flux. From the flame spread theory, this would give a faster flame spread rate, as shown here.

Given that particle board is a common material used in flame spread testing, this shows the limitation in comparing "equivalent" materials.

The effect of preheating the material on the variation of the flame spread rate measured in the RIFT can be seen by comparing Figure 62 and Figure 63. It can also

be seen in the amount of data scatter in the flame spread correlation (Figure 64) when compared to the same material which is fully preheated (Figure 65).

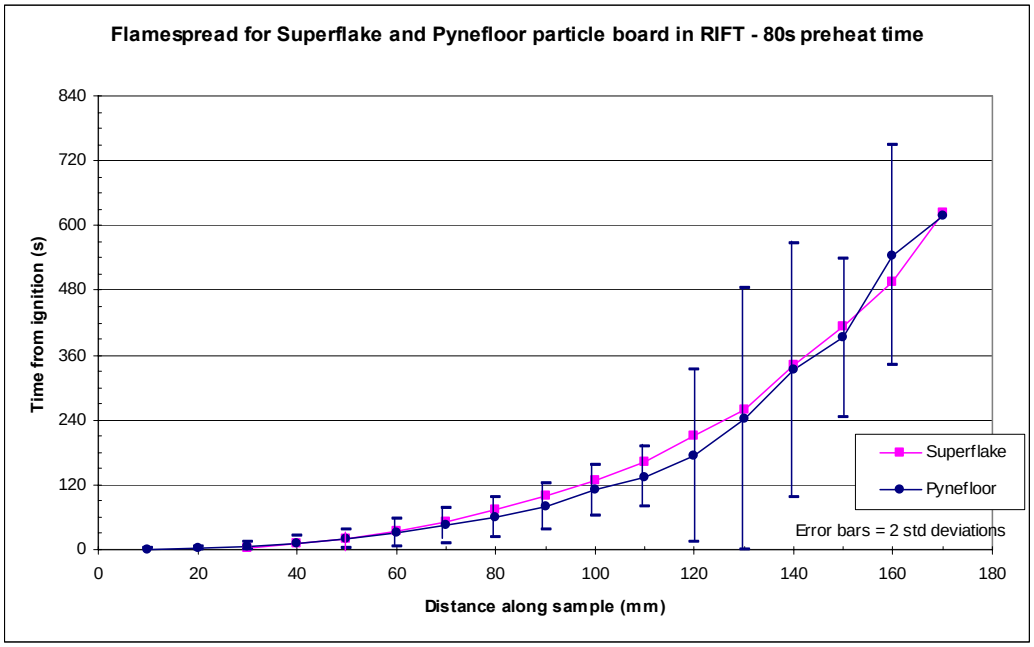



**Figure 62: Comparison of flame spread of 2 brands of particle board – low preheat time**

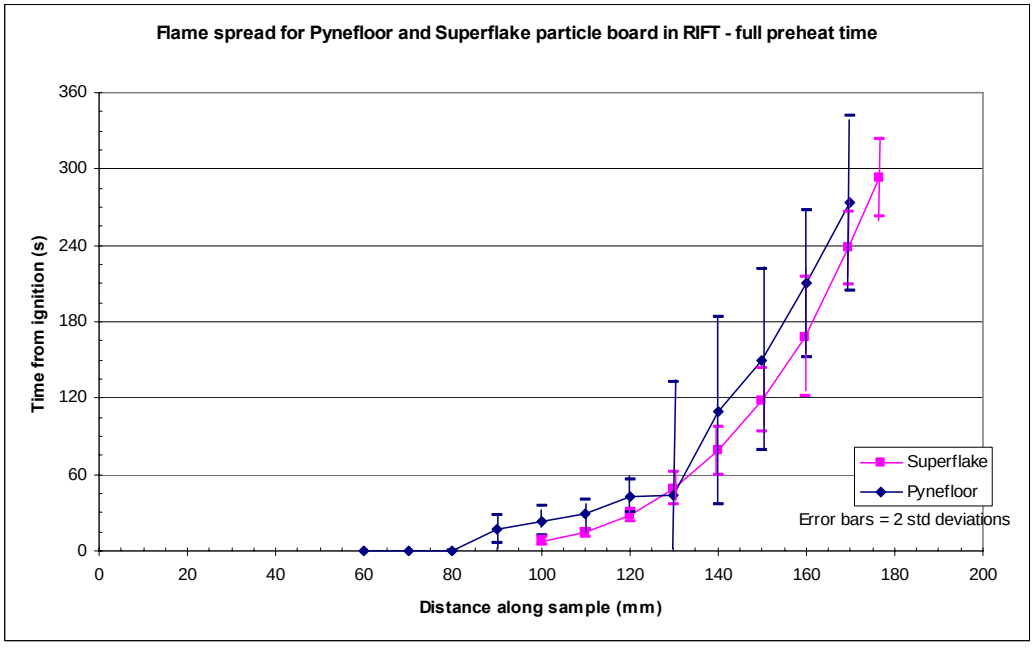



**Figure 63: Comparison of flame spread for 2 brands of particle board - full preheat time**

The flame spread correlation for the Pynefloor in the RIFT is affected by outliers at the end of the test (Figure 65) – i.e. at the period of low flame spread rate. Without

these, the results would be a better match to those obtained in the LIFT (Figure 68). The Superflake board was not tested in the LIFT as there was insufficient material to conduct a full suite of LIFT tests.

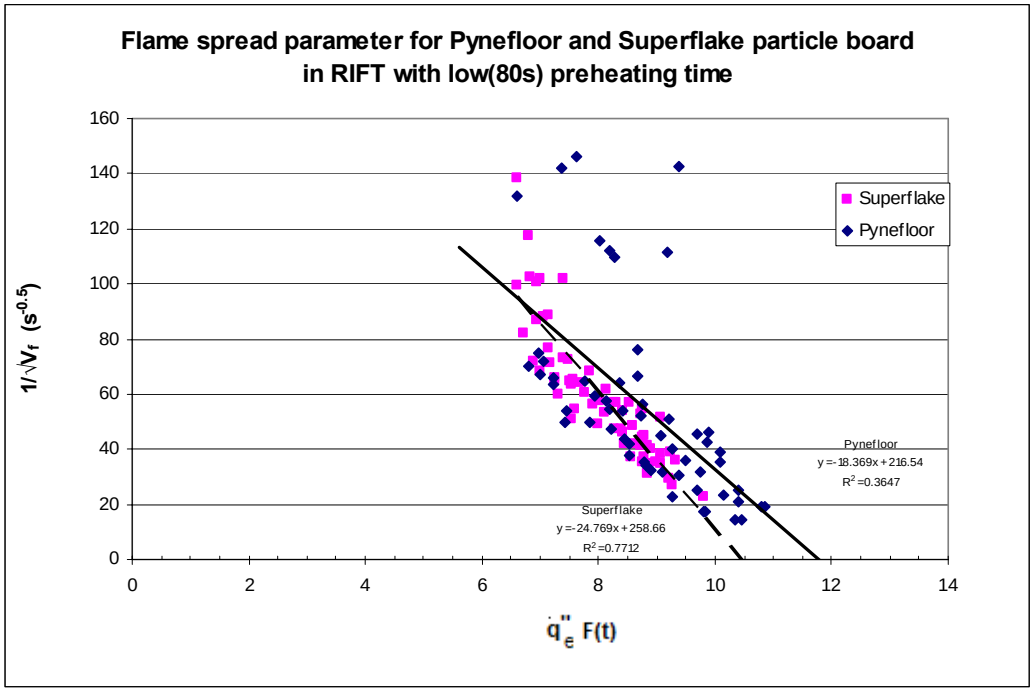



**Figure 64: Flame spread parameter for Superflake and Pynefloor particle board in RIFT with a 80s preheat time.**

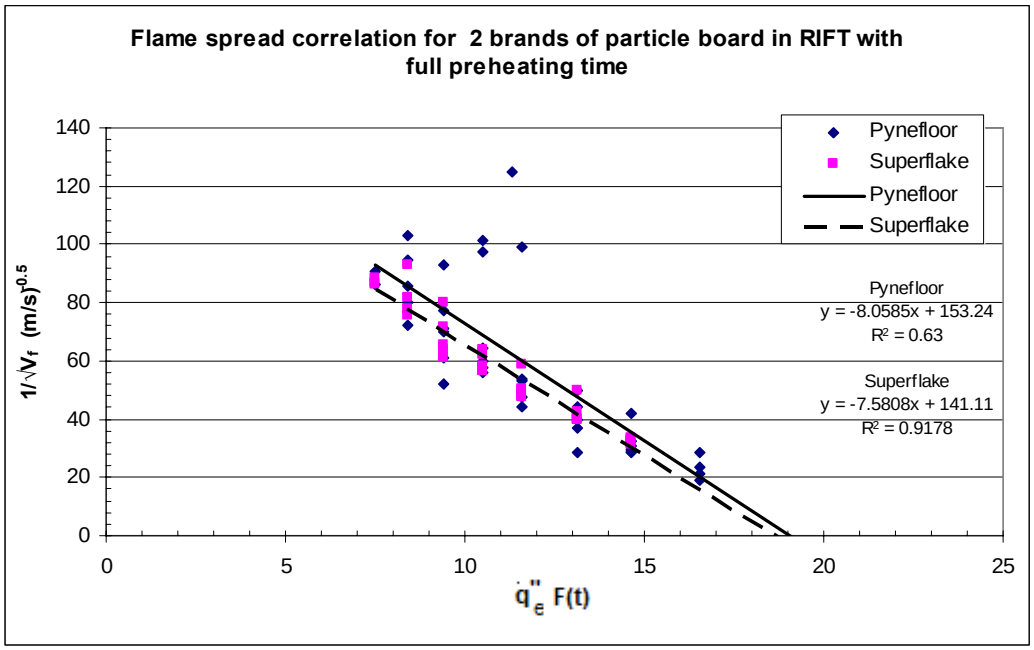



**Figure 65: Flame spread correlation for 20mm Particle board in RIFT with full pre-heating time.**

*Flame spread for particle board in the LIFT*

The LIFT was set to the flux profile shown in Figure 66 and the samples preheated for the preheating time based on the LIFT ignition results of $t^{*}$= 386 seconds prior to ignition.

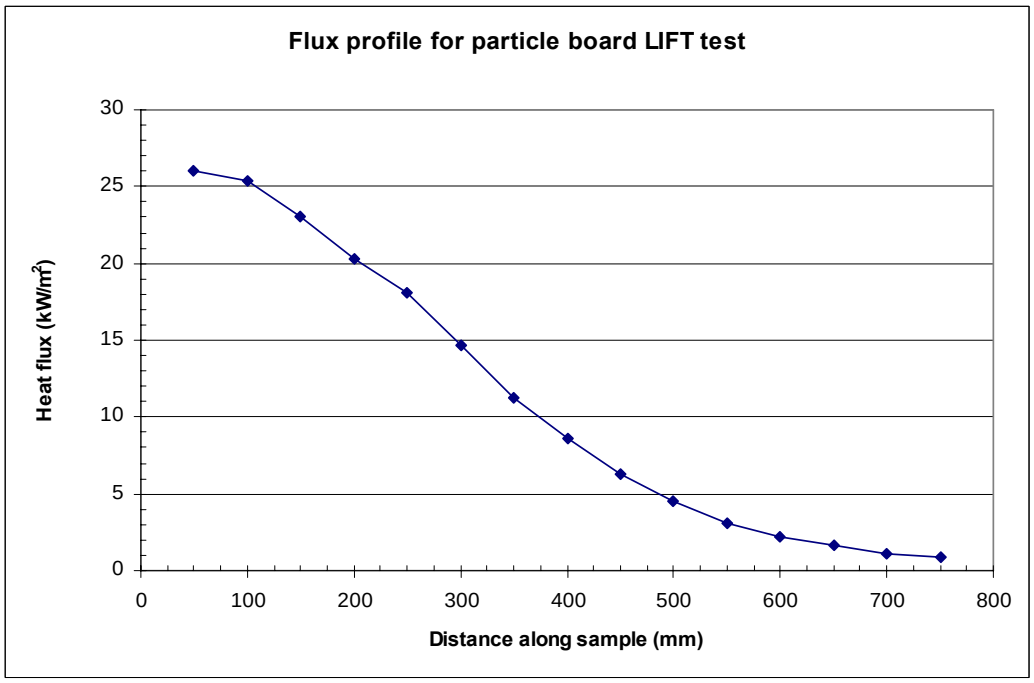


**Figure 66: Heat flux profile for LIFT flame spread tests on particle board**

The resulting flame spread along the sample is shown in Figure 67.

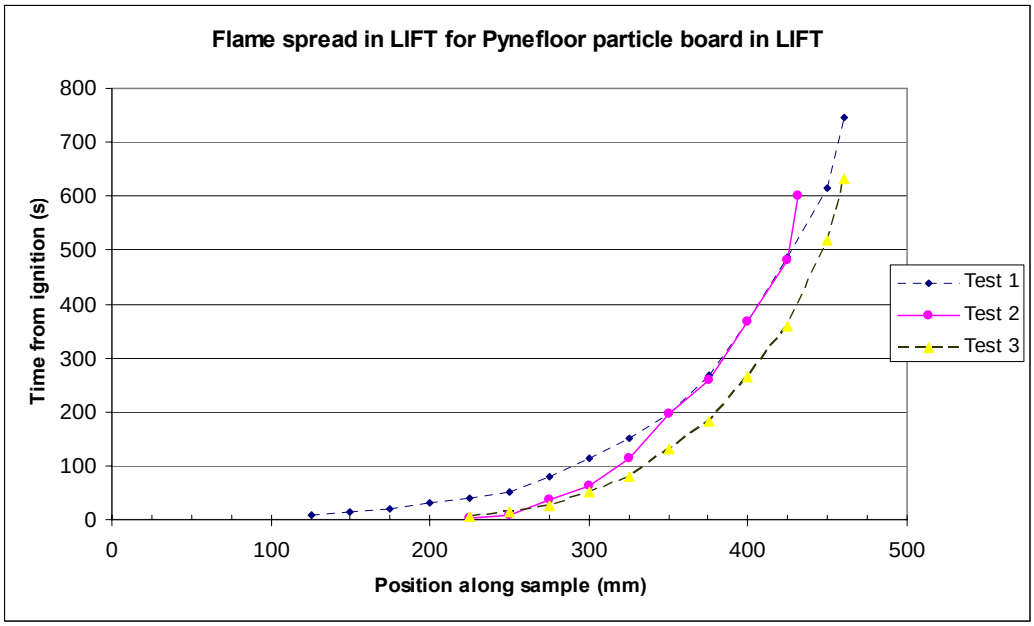



**Figure 67: Flame spread in LIFT for Pynefloor particle board**

The resulting flame spread correlation for Pynefloor is compared to the same material in the LIFT in Figure 68, where the value of the minimum flux for flame spread is similar, but the RIFT gives a lower correlated value of the minimum ignition flux. In both tests, the material was fully preheated, with the RIFT test using the ISO 5657 ignition test data, and the LIFT using the ignition data from the LIFT ignition tests.

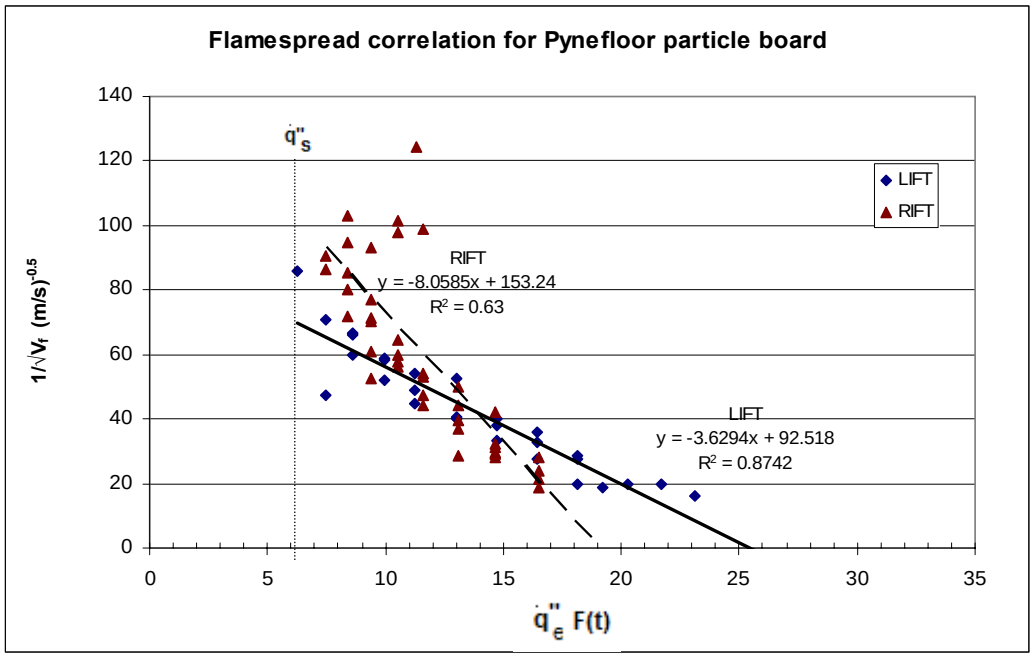



**Figure 68: Flame spread correlation for 20mm Pynefloor particle board in LIFT and RIFT**

## *8.3 Plywood*

All samples were from a single sheet of IPL "Tuffply" 17mm untreated Radiata Pine C/D grade plywood. The smooth (C grade) face was used for the ignition and flame spread tests.

### 8.3.1 Ignition of plywood

The time to ignition for varying flux levels is shown in Figure 69.

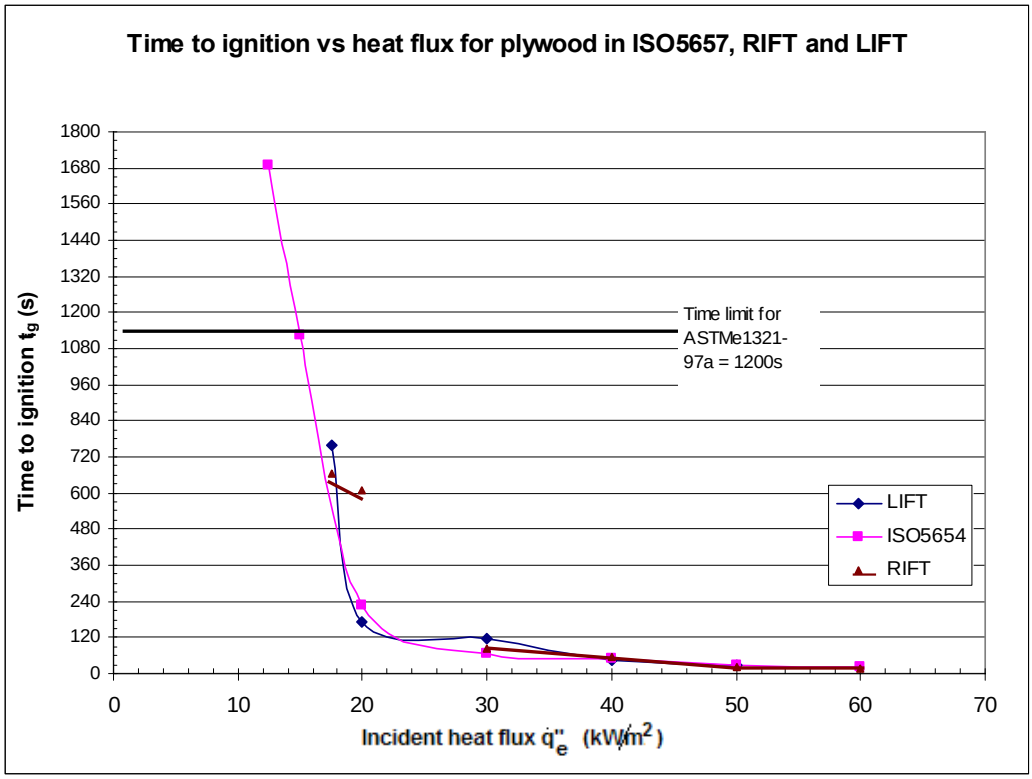



**Figure 69: Time to ignition for 17mm plywood**

As can be seen in Figure 69, the fact that the sample does not ignite within the time limit does not mean that the minimum ignition flux is the lowest point that ignition will occur. In the case of this ignition test, the sample had a glowing spot before finally igniting, and there was considerable charring.

The critical ignition flux (Figure 70) for plywood by the 3 ignition methods gave a range of results from 4.6kW/m$^2$ to 10kW/m$^2$, compared with 13.75kW/m$^2$ for the

minimum ignition flux in the ISO 5657 test and 16.25kW/m$^2$ for the RIFT and LIFT ignition tests.

The chart for the ignition parameter (Figure 71) shows less spread of the results than with the particle board (Figure 56), largely due to the minimum ignition flux being similar for all test methods. Values above $\dot{q}''_{ig,\min}/\dot{q}''_e$<0.8 were ignored to improve the data fit.

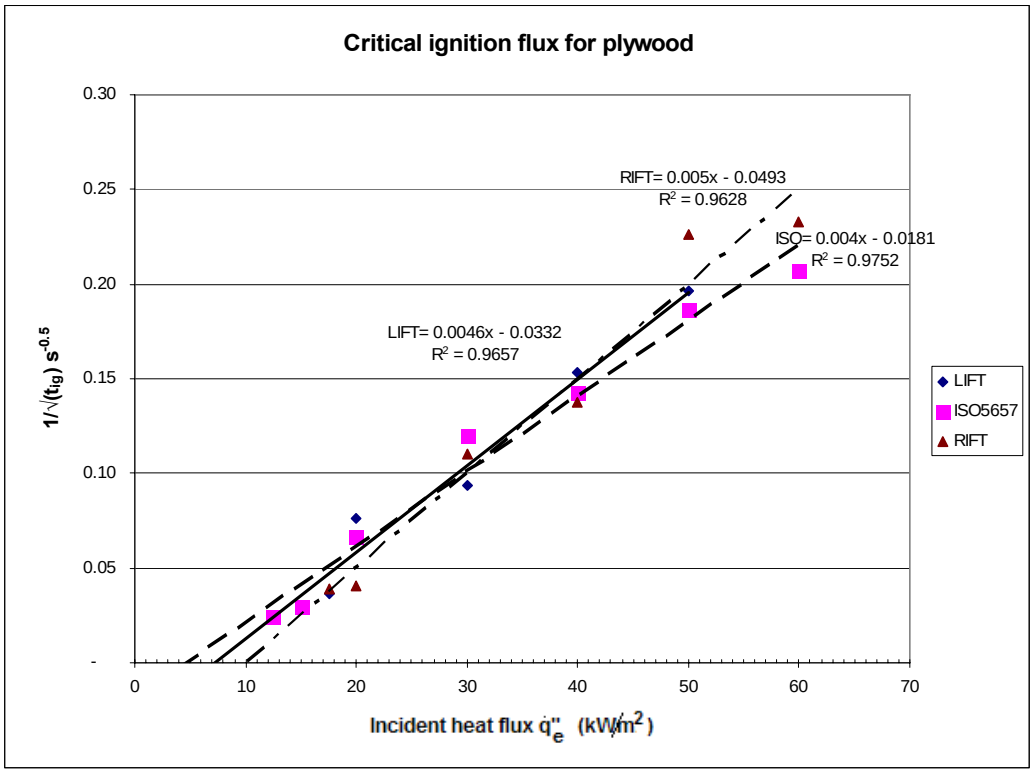



**Figure 70: Critical ignition flux for plywood**

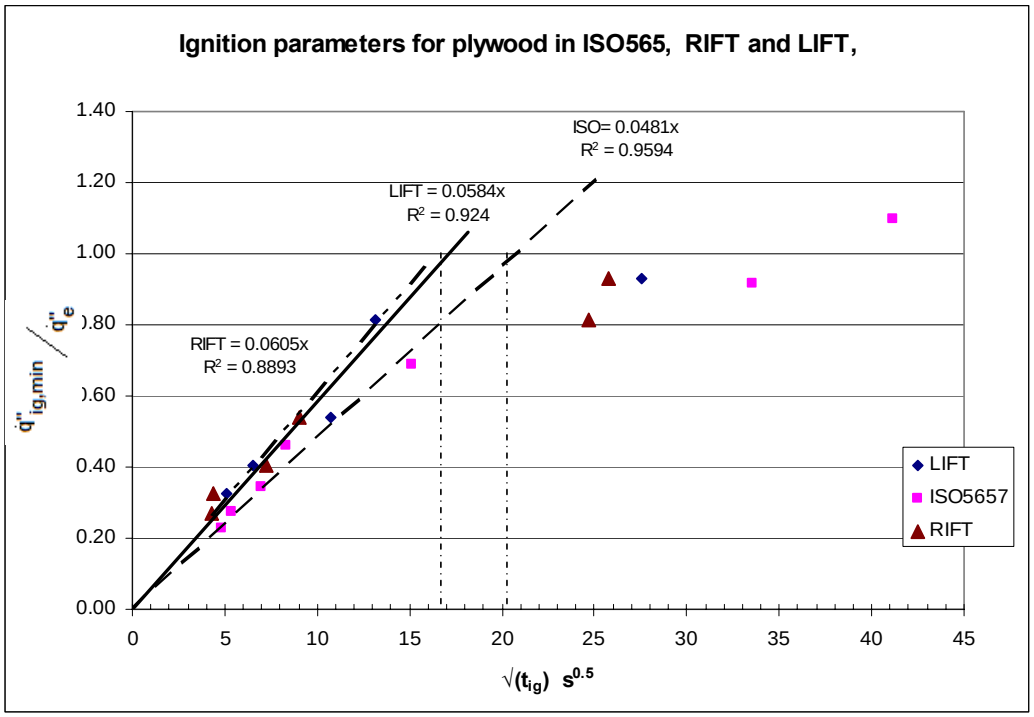



**Figure 71: Ignition parameter for plywood**

### 8.3.2 Flame spread of plywood

*Flame spread in RIFT*

The flame spread in the RIFT shows the expected behaviour, with the preheated sample having a faster flame spread rate, due to the higher initial surface temperature. The low preheat time was approximately 65 seconds., compared with the preheat time for the LIFT at 293 seconds, and the full preheat time for the RIFT , based on the ISO 5657 ignition data of 432 seconds.

The flame spread along the sample is given in Figure 72, showing the effect of preheating on the flame spread rate and the extent of flame spread. The flame spread rate is sufficiently slow compared with the preheating time that the sample can preheat to equilibrium at the extent of flame spread. The extent of flame spread along the sample is therefore the same in both cases. The velocity of the flame front is less for the sample which is not preheated, reflecting the lower initial surface temperature prior to ignition.

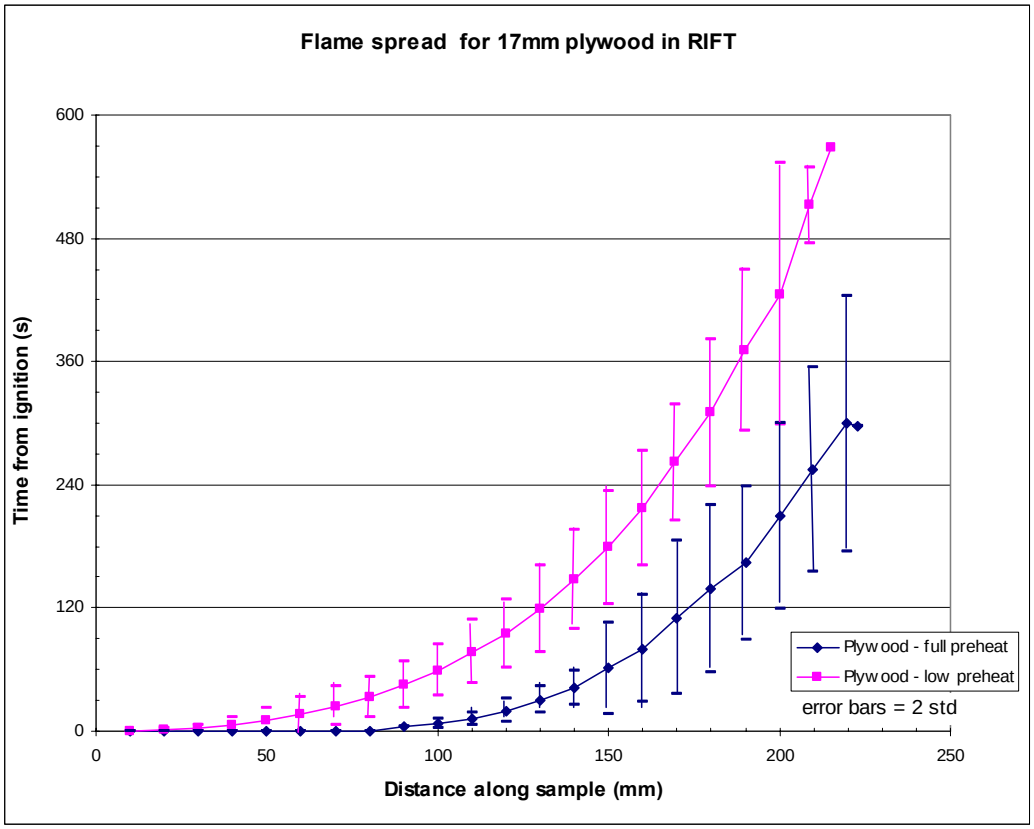



**Figure 72: Flame spread of 17mm plywood in RIFT**

Both 9mm and 17mm plywood were tested without a preheating period, to check if the material thickness had any significant effect on the flame spread. In this case, the difference in the flame spread is within the limits of error and there is no significant difference (Figure 73). Different materials and a long preheating time may alter this result, if the material thickness is less than the thermal penetration depth.

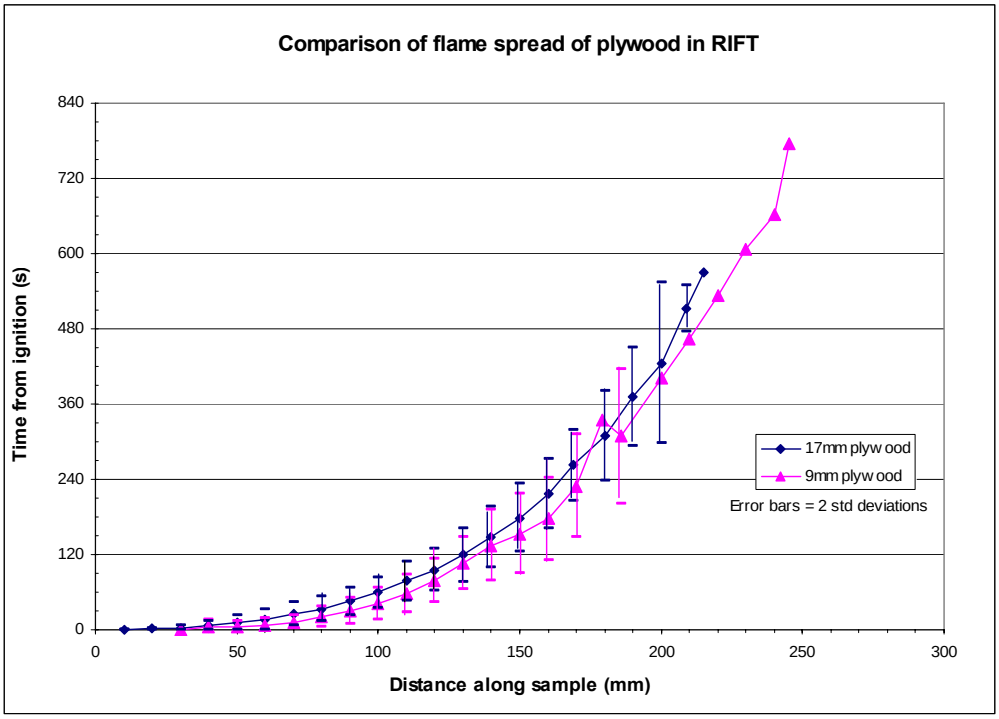



**Figure 73: Comparison of flame spread with different thicknesses of plywood**

The resulting flame spread correlation from the RIFT flame spread tests is shown in Figure 74.

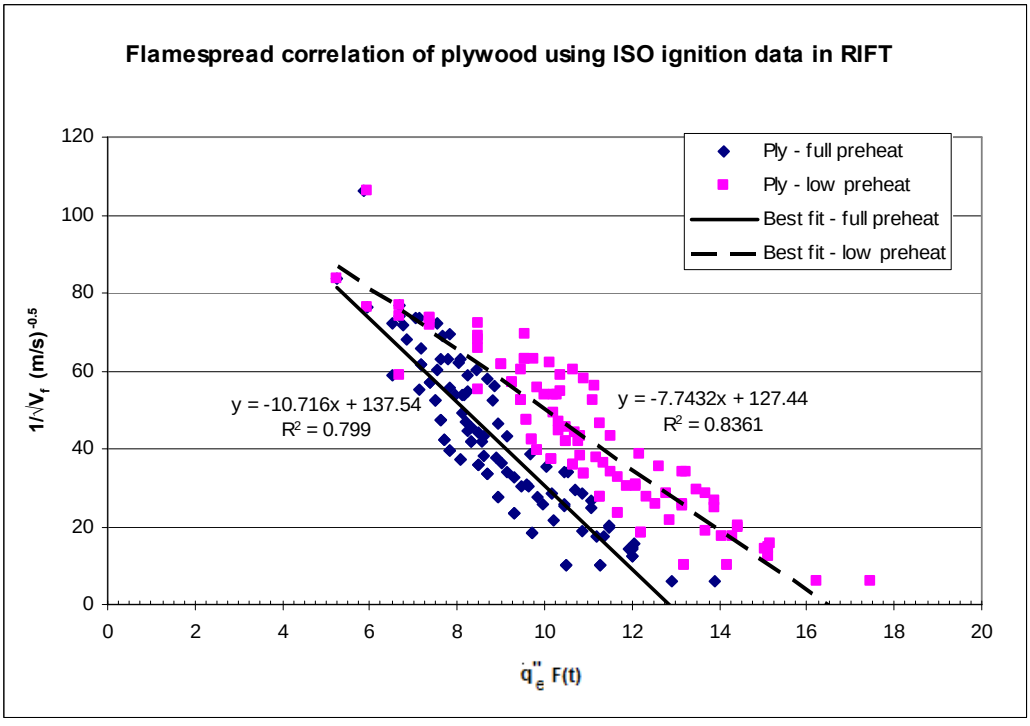



**Figure 74: Flame spread correlation for 17mm plywood in RIFT**

*Flame spread in LIFT*

The flame spread tests in the LIFT used the heat flux profile shown in Figure 75 with the resulting flame spread along the sample shown in Figure 76.

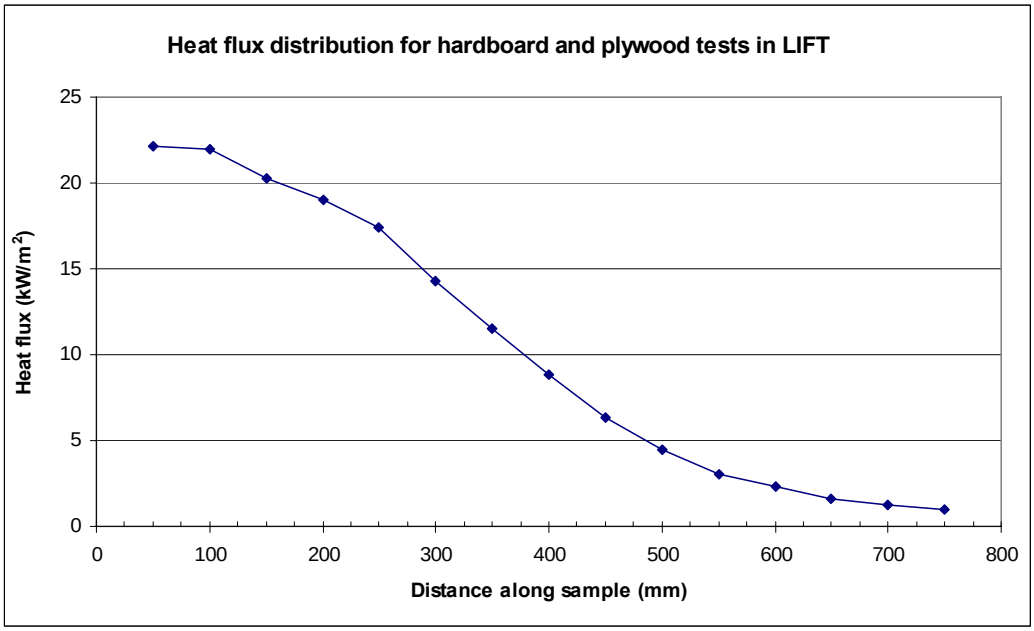



**Figure 75: LIFT heat flux profile for plywood and hardboard flame spread tests**

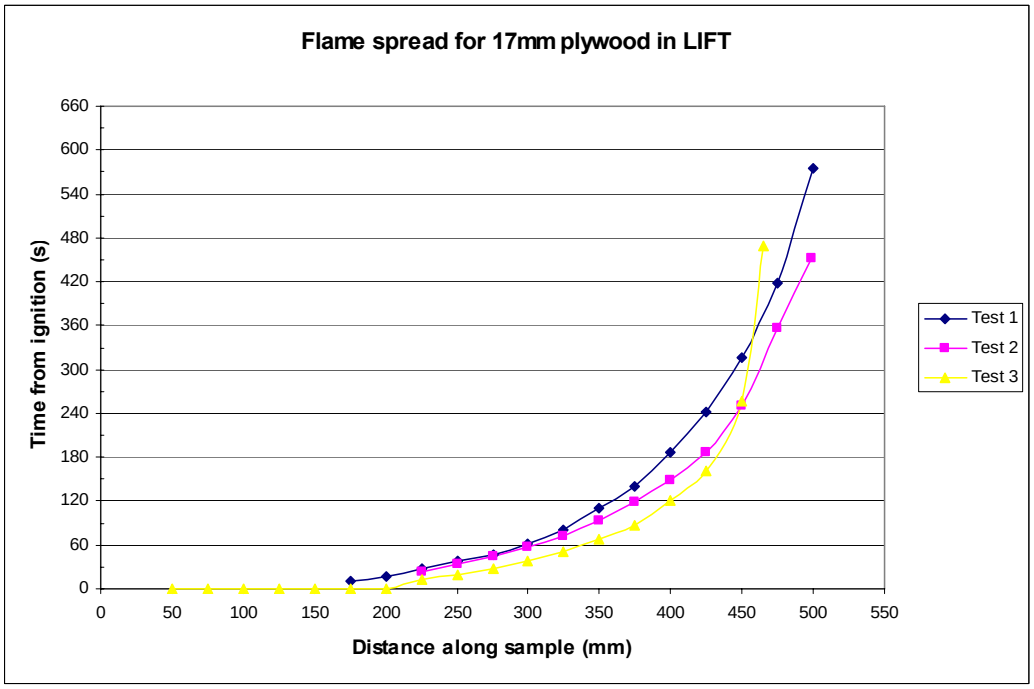



**Figure 76: Flame spread for 17mm plywood in LIFT**

The flame spread correlation (Figure 77 and Figure 78) shows that the RIFT and LIFT gave similar results, however the RIFT has more data scatter than the LIFT.

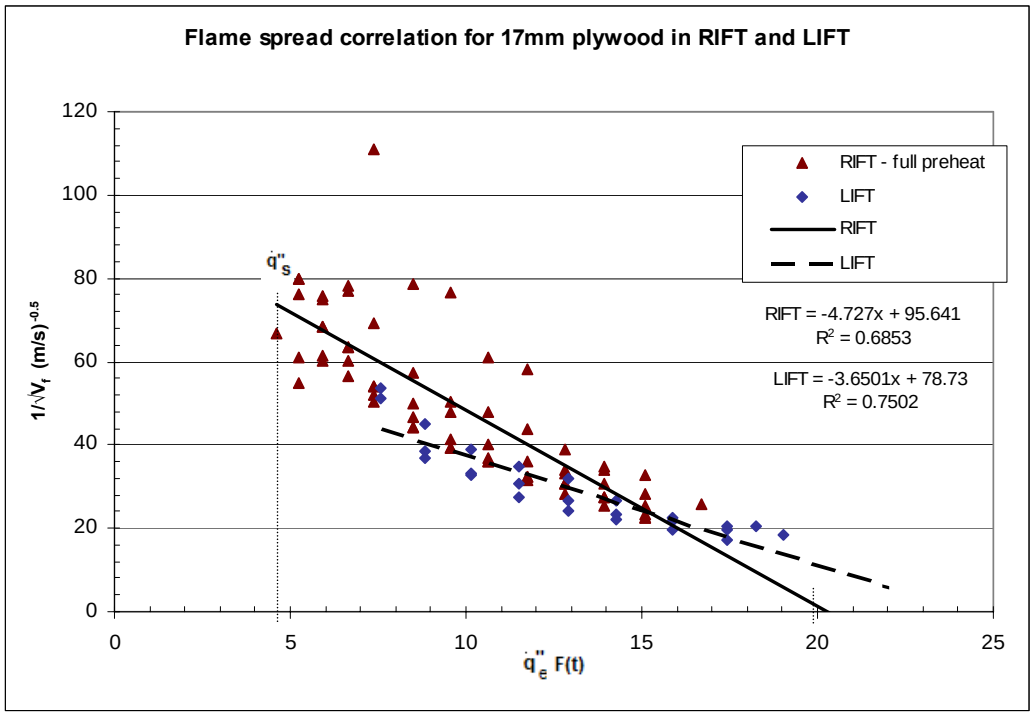



**Figure 77: Flame spread correlation for 17mm plywood in RIFT and LIFT**

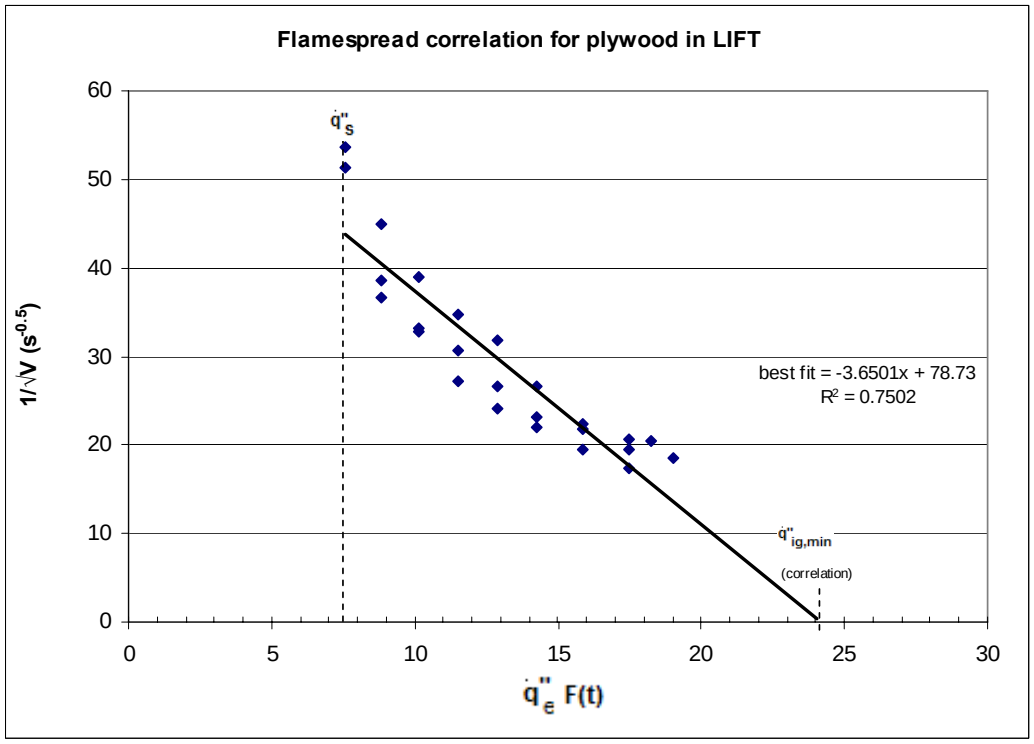



**Figure 78: Flame spread correlation for plywood in LIFT**

## *8.4 Hardboard*

The material used here was a generic unbranded material from a builders supply merchant, with a thickness of 5mm.

### 8.4.1 Ignition of hardboard

The sample in the ISO 5657 ignition test was backed with 20mm lightweight Kaoboard low density insulating board. The RIFT ignition test used 12mm lightweight Kaoboard. The LIFT uses a higher density CaSi board, and this may affect any time to ignition comparison, as the material is physically thin in comparison to the other materials tested. Attempts to calculate the thermal thickness of the hardboard showed to much variation to be successful. Quintiere and Harkleroad (1984) found little difference attributable to the density of the backing board – the expected result for a thermally thick material.

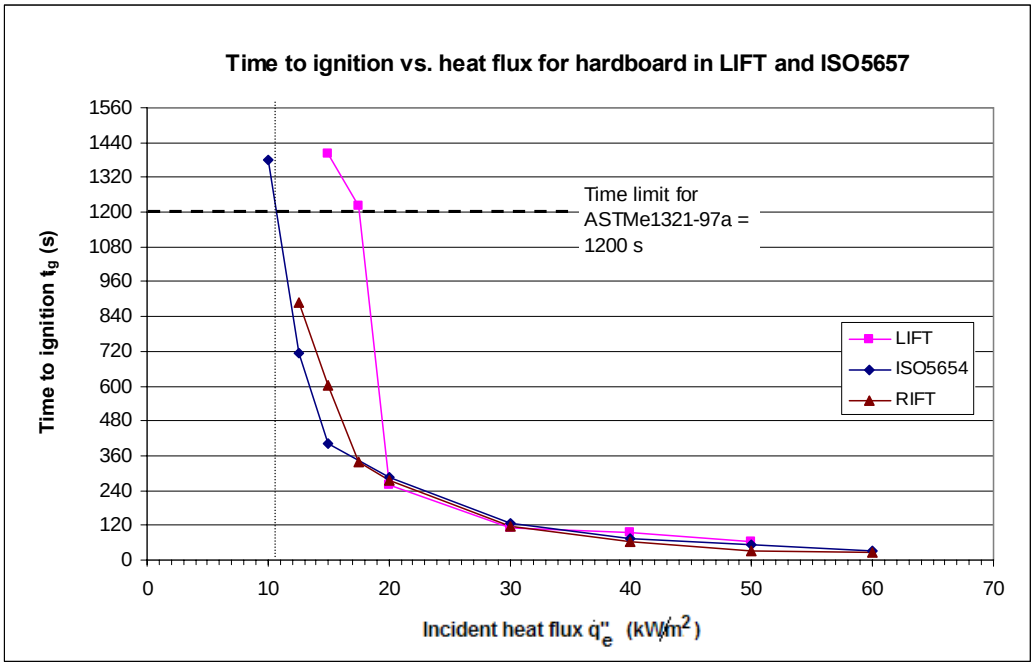



**Figure 79: Time to ignition of hardboard**

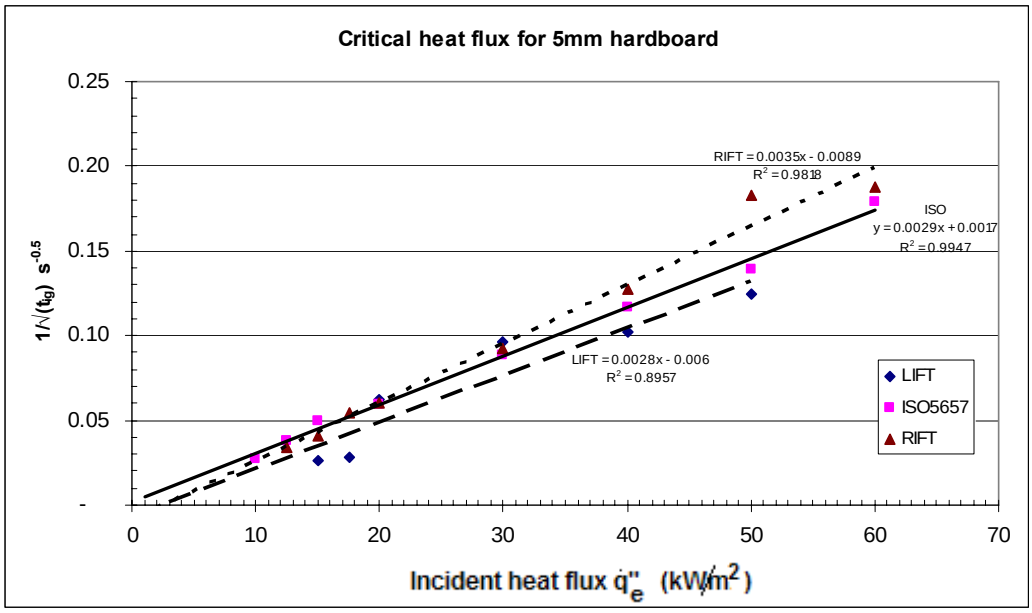



**Figure 80: Critical heat flux for hardboard**

The ignition parameter (Figure 81) shows considerable spread between the LIFT and ISO ignition results. The calculated preheat time $t^*$ from the ISO 5657 ignition tests of 944 seconds is unrealistically long, as the material chars and collapses before this time can be achieved in the flame spread test. The ignition test conducted in the RIFT gave a preheat time of 977 seconds, compared with the LIFT calculated preheating time of 375s.

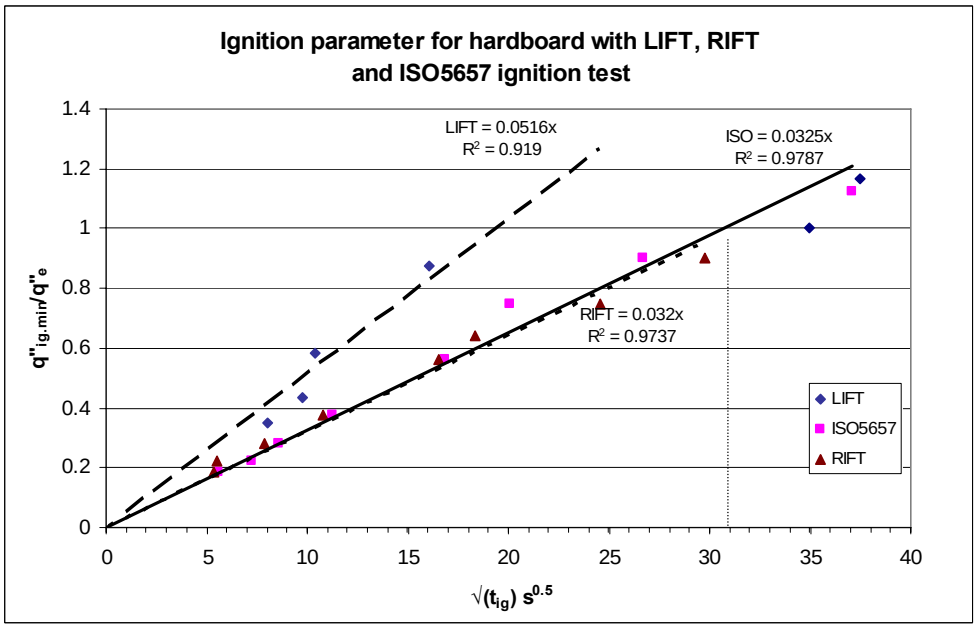



**Figure 81: Ignition parameters for hardboard**

### 8.4.2 Flame spread of hardboard

*Flame spread of hardboard in the RIFT*

Five repeat runs were conducted with hardboard in the RIFT, and they produced consistent flame spread results between runs in the RIFT and LIFT (Figure 83 and Figure 86), in spite of the behaviour of the material during preheating and burning. The material cracks behind the flame front area (Figure 82) which allows the pyrolised material to open and potentially allow flames to the rear of the sample.

With low preheat times, the area of the flame front appears to be unaffected until after the flame has passed and it does not appear to affect the flame spread correlation (Figure 85). The correlation is less accurate with more scatter when the material is given the full preheat time (Figure 87), possibly due to both the material cracking and increasing thermal penetration of the material, making the assumption that the material is thermally thick less valid.

A particular problem is the long preheat time dictated by the RIFT and ISO 5657 ignition results and the calculated ignition parameter (Figure 81) was unobtainable in the RIFT, as the sample charred to such an extent that pieces of the sample fell out and the sample self ignited. The preheating time used was therefore the time calculated from the LIFT ignition tests.

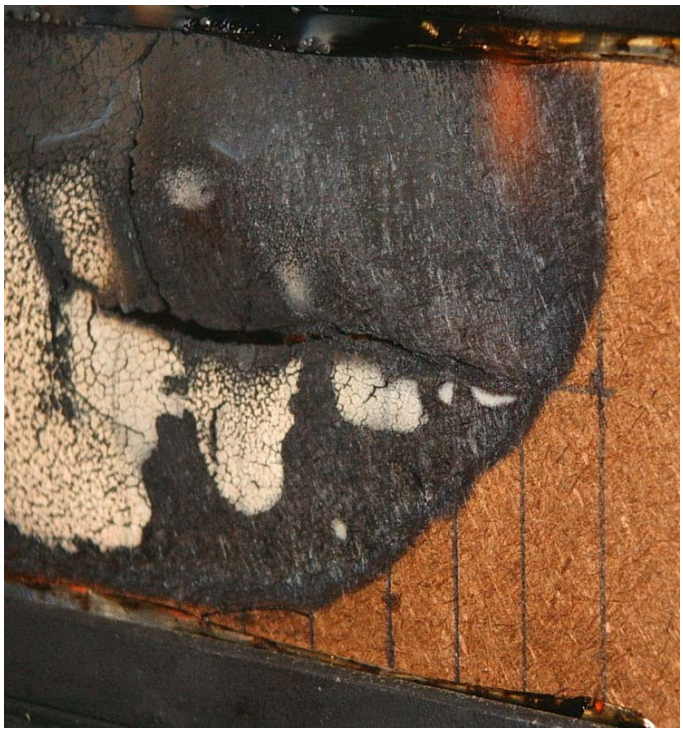


**Figure 82: Cracking behind the flame front on hardboard**

The consistent flame spread performance during the initial part of the flame spread test gives a good correlation result (Figure 85), with less data scatter for low preheat times, unlike the other products tested; where the data scatter is greater with a low preheat time. The data scatter in the correlation also increases significantly at the end of the flame spread test, possibly due to thermal penetration, and the material cracking and flames getting behind the sample.

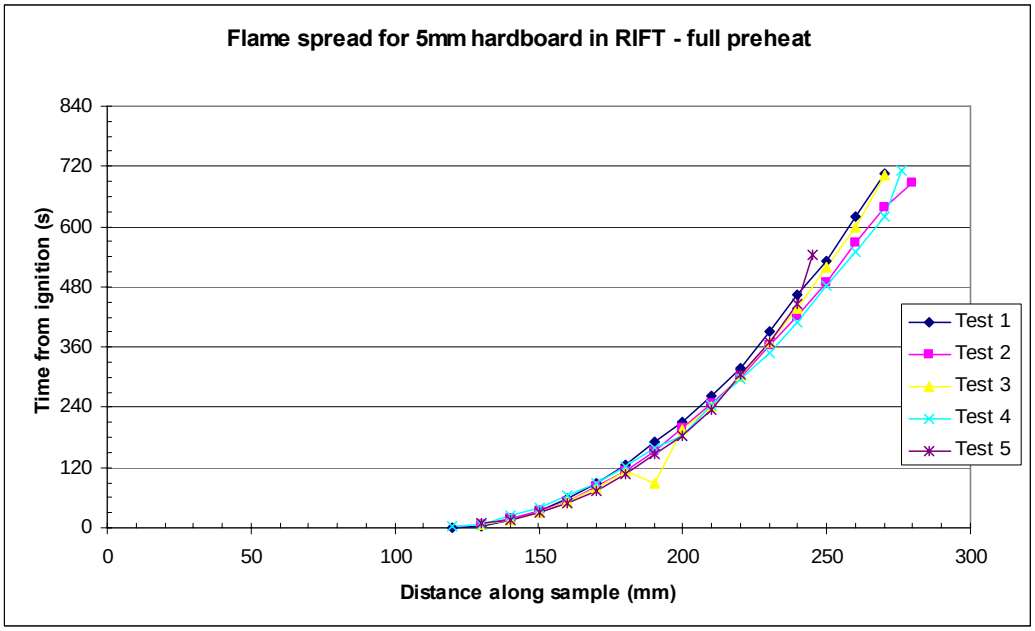



**Figure 83: Flame spread of hardboard in RIFT – full preheat time**

Comparing the flame spread for the different preheating times shows the expected behaviour, where the preheated sample has a higher flame spread rate (Figure 84).

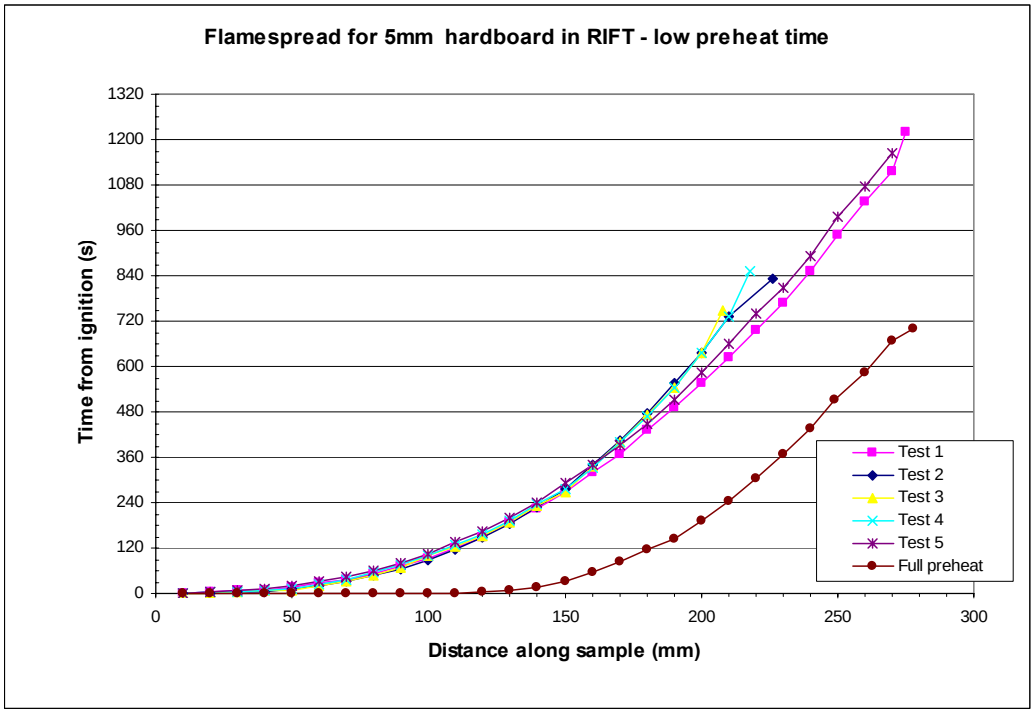



**Figure 84: Flame spread for hardboard in RIFT – low preheat time**

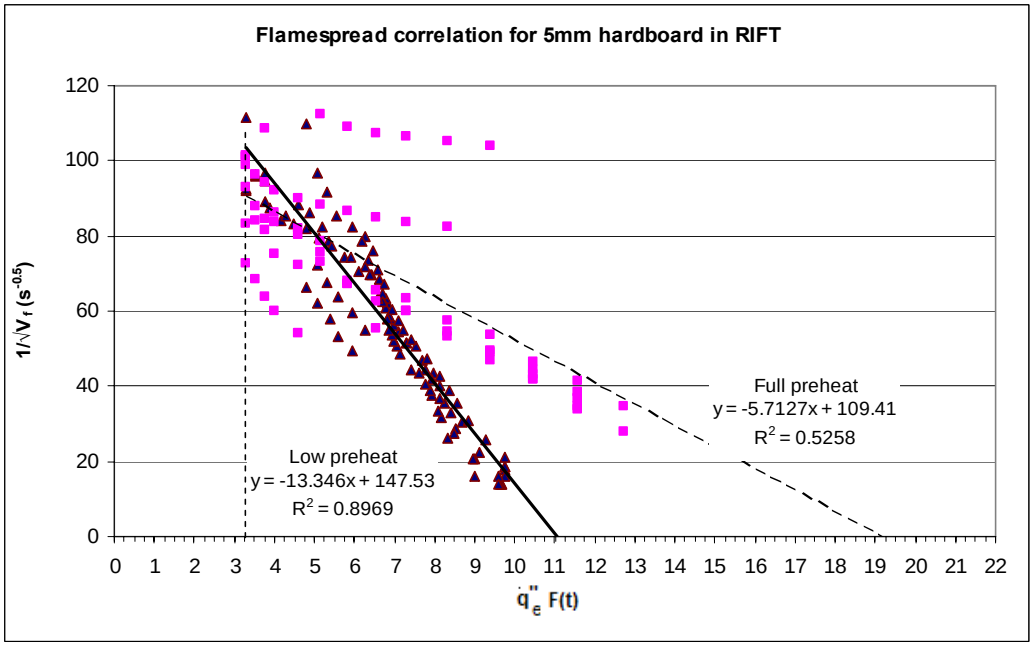



**Figure 85: Flame spread correlation for hardboard in RIFT**

The flame spread correlation for the RIFT with a full preheat period is compared to the results from the LIFT in Figure 87.

*Flame spread for hardboard in the LIFT*

The heat flux distribution for the LIFT tests is shown in Figure 75, and the resulting flame spread for hardboard in the RIFT is given in Figure 86.

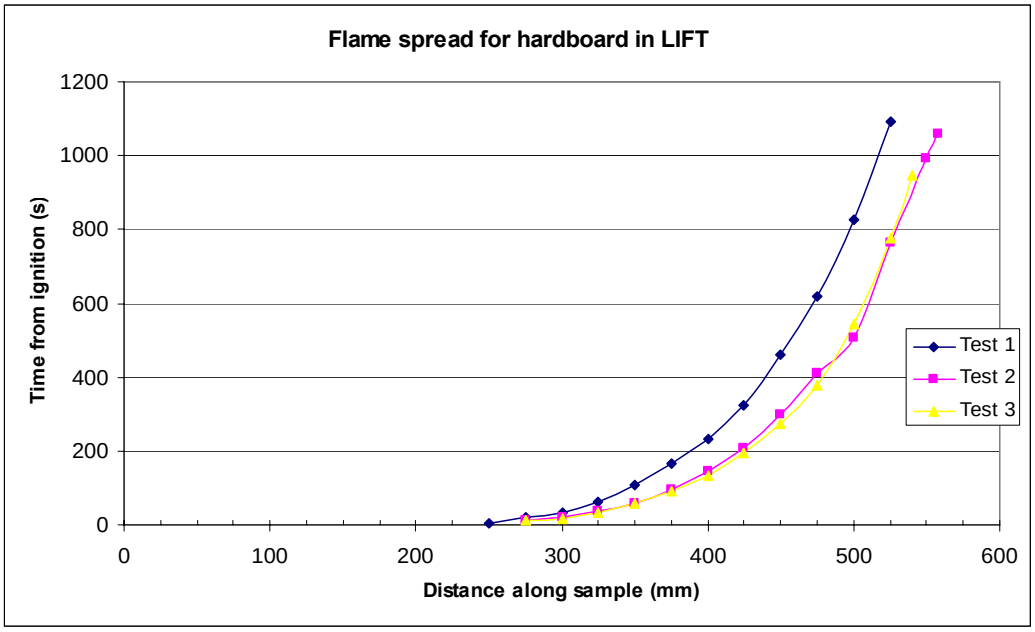



**Figure 86: Flame spread of hardboard in LIFT**

The results for the flame spread correlation from the RIFT closely match those for the LIFT (Figure 87), although the LIFT results have much less data scatter.

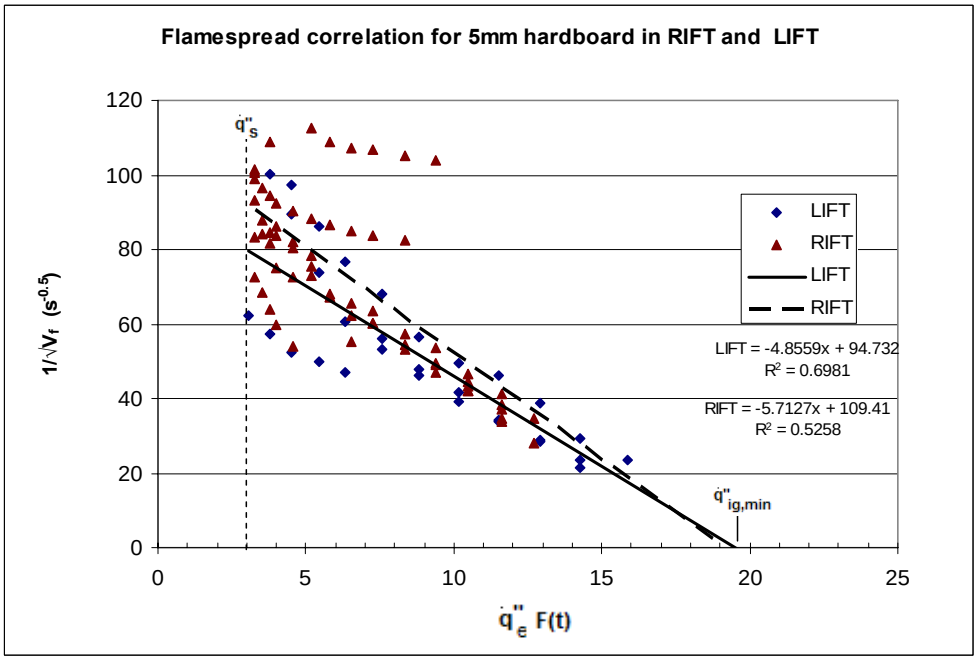



**Figure 87: Flame spread correlation for hardboard in RIFT and LIFT**

### 8.4.3 Melteca

The flame spread of two samples of melamine sheet products were compared in the RIFT to determine the variation between materials. One was a generic white Melteca faced board, using a MDF substrate, manufactured by Fletcher Wood Panels, and sold through builder's merchants and panel suppliers. The other was "Regal" brand shelving with a particle board substrate, sold as prefinished and clashed boards in hardware and builders supplies.

Only the Melteca- MDF sheet was tested in the LIFT, due to the amount of material available from the shelving product. The results from the RIFT tests and the Melteca-MDF results from the LIFT indicated that further testing in the LIFT of the Melteca – particle board material was not required due to the inconsistent flame spread results.

The ignition and flame spread behaviour of Melteca shown in Figure 88 is typical. The facing material starts to bubble at relatively low heat fluxes, insulating the substrate material. The flame front only progresses as the facing peels off or the bubbles split, allowing the pyrolised substrate to escape, and this gives erratic flame spread rates and ignition times.

**Figure 88: Flame spread behaviour of Melteca faced board**

### 8.4.4 Ignition of Melteca faced boards

The addition of the melamine (Melteca) facing affects the ignition and hence the flame spread of the samples. The facing board bubbles and chars at lower flux levels than the underlying material, thus insulating the underlying substrate, however it does not ignite easily. The substrate pyrolizes and as the surface bubbles split, the gas escapes and can ignite. As a result, at low flux levels, the ignition time can become erratic. This behaviour also affects the flame spread, giving erratic flame spread results.

The insulating property of the facing material is apparent when comparing the ignition flux to that of the bare substrate material.

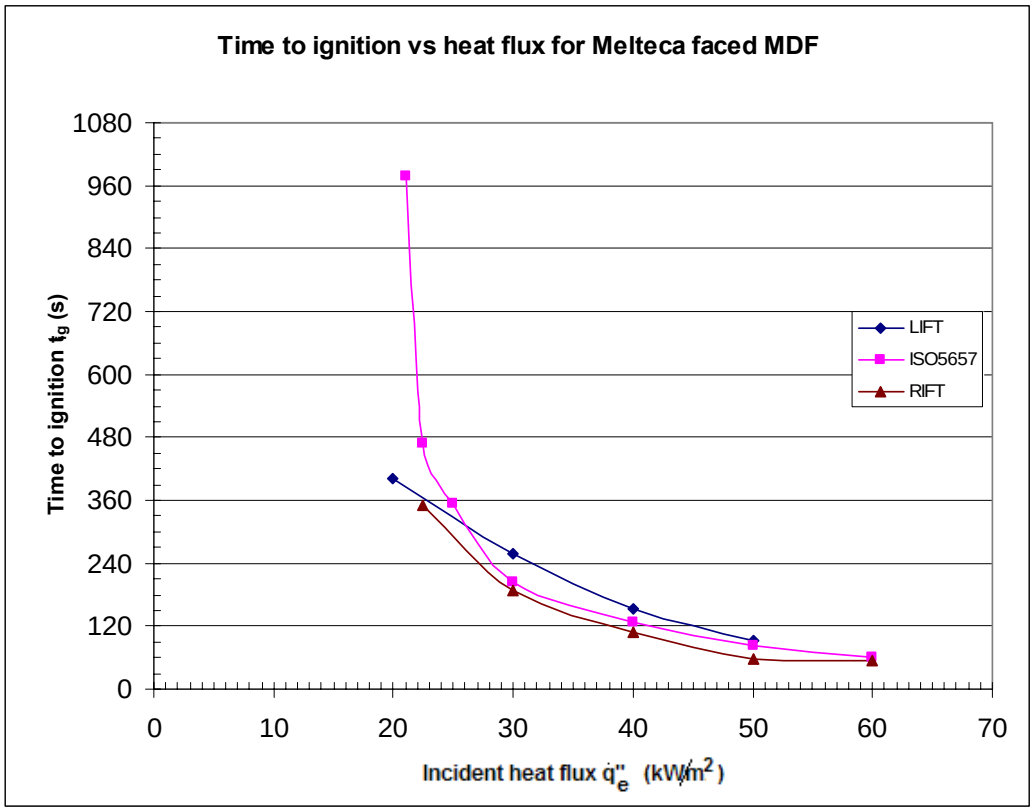



**Figure 89: Time to ignition vs. heat flux of Melteca/MDF board**

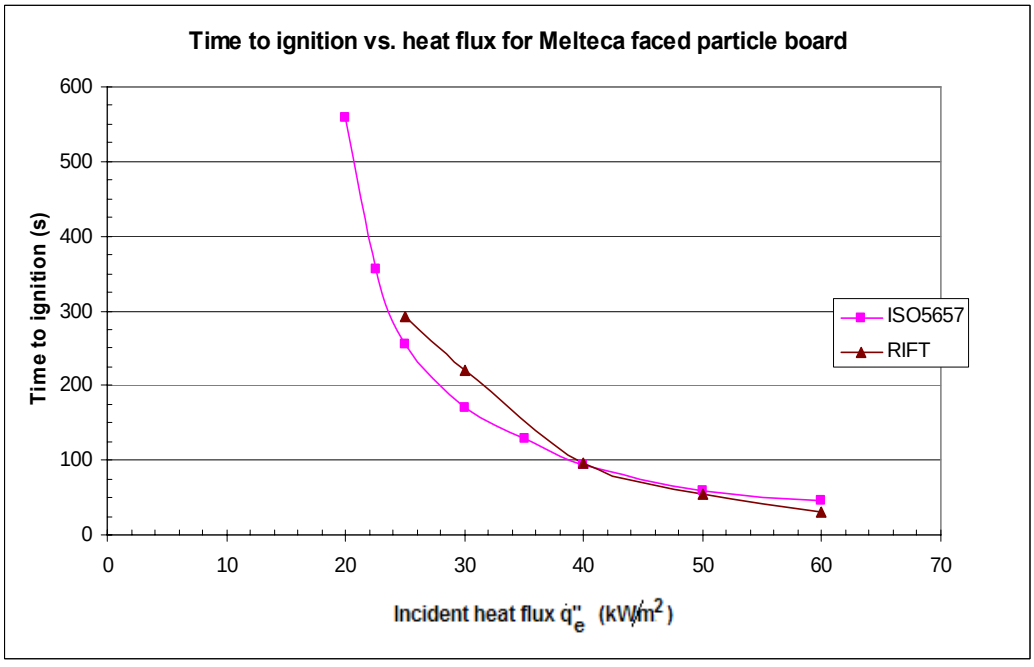



**Figure 90: Time to ignition for Melteca faced particle board**

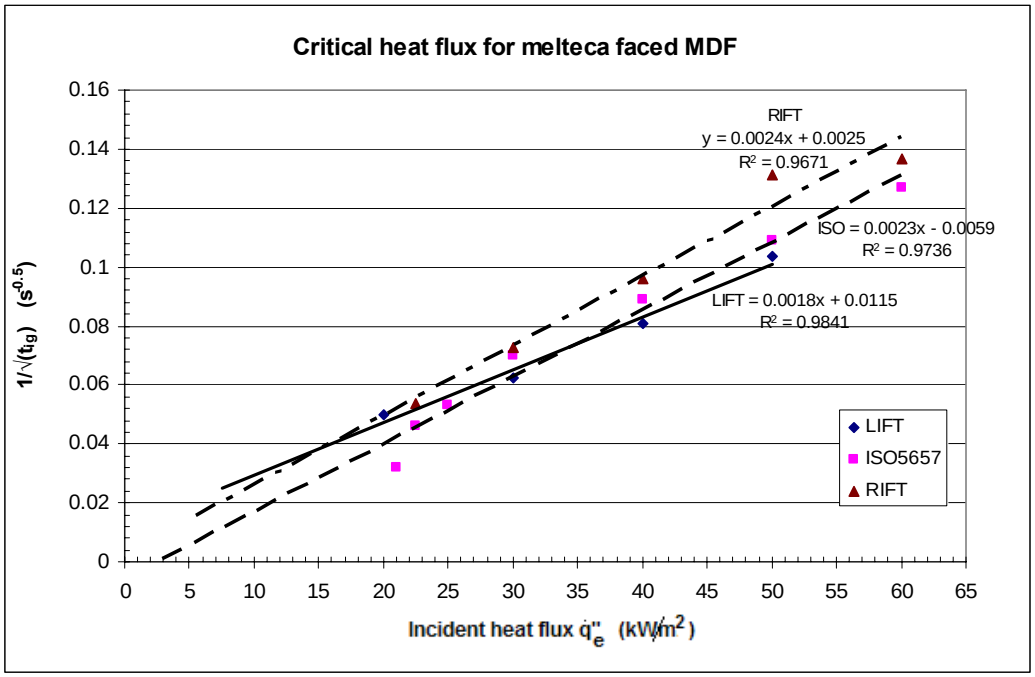



**Figure 91: Critical ignition flux for Melteca faced MDF**

The results are given in Appendix 3.

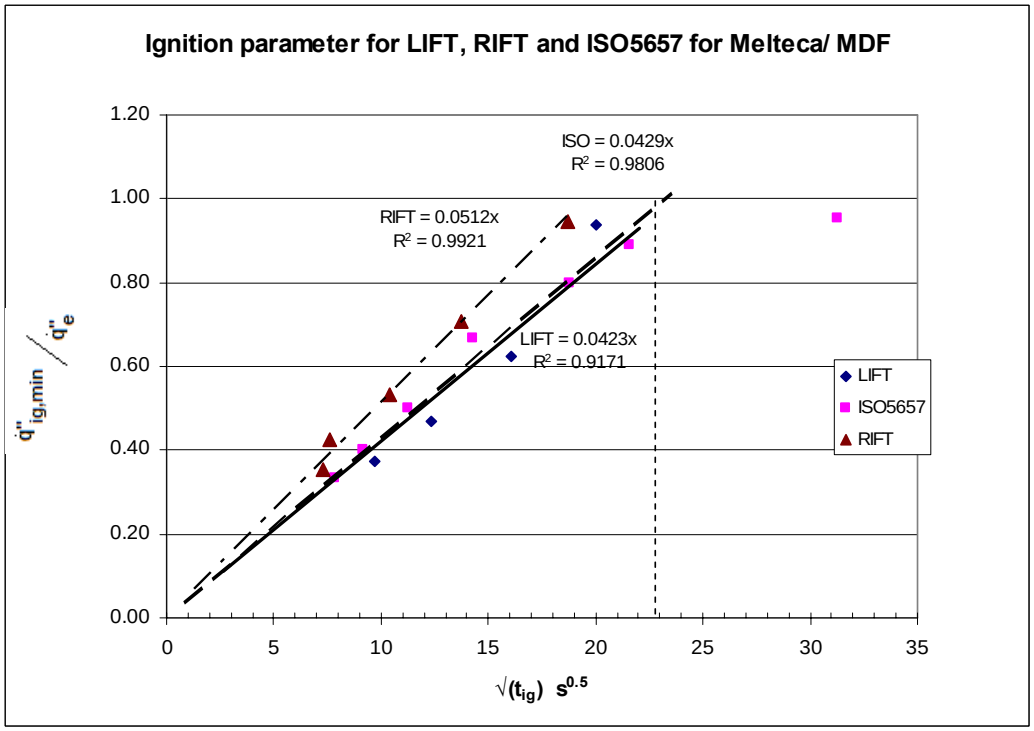



**Figure 92: Ignition parameter for Melteca/ MDF board**

*Comparison of ignition results between two substrate materials*

Comparing the time to ignition of the two Melteca boards with the different substrate materials (Figure 93) shows that the particle board based material ignited faster than the MDF based board, and this is reflected in the flame spread rate, as discussed in the following section.

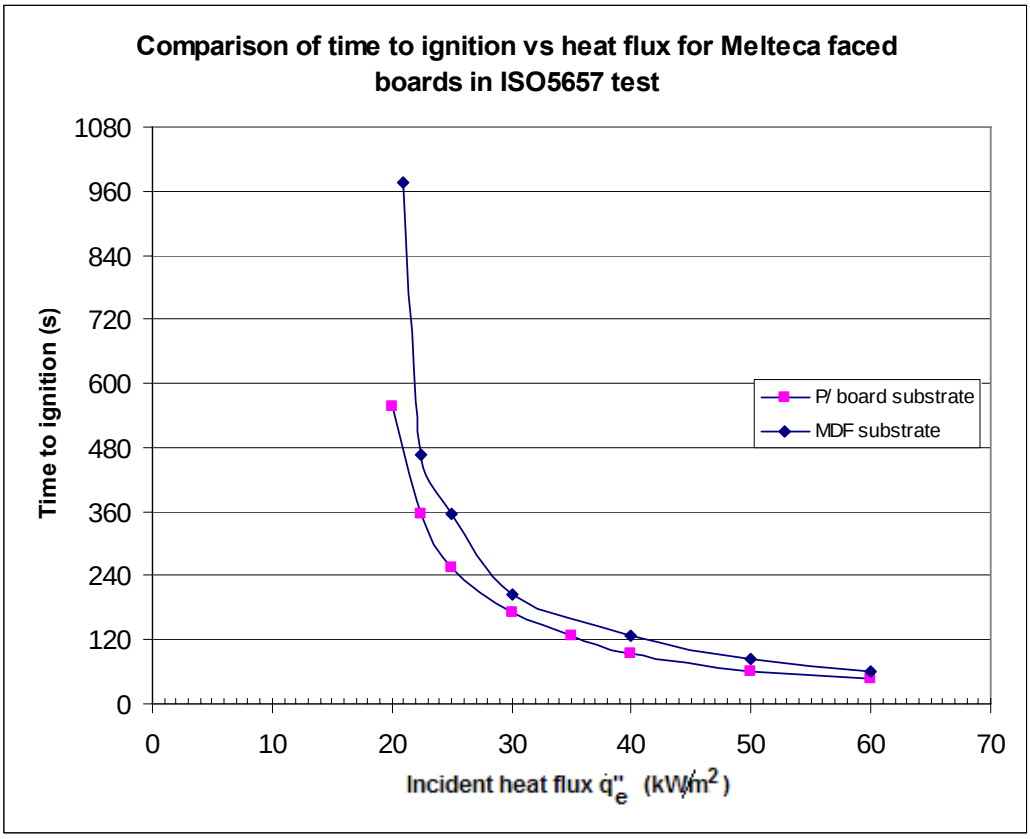



**Figure 93: Time to ignition vs. heat flux for Melteca faced boards**

### 8.4.5 Flame spread of Melteca

*Flame spread in RIFT*

Six samples of each material were tested in the RIFT, both with a preheating period and with no preheating prior to ignition. It was not possible to derive a flame spread correlation for Melteca faced boards in the RIFT with no preheating, as there was no linearity and it was not possible to fit a line to the data. The effect of the substrate can be seen in Figure 94, where the MDF based board has a slower flame spread rate than the particle board based material, reflecting the ignition results.

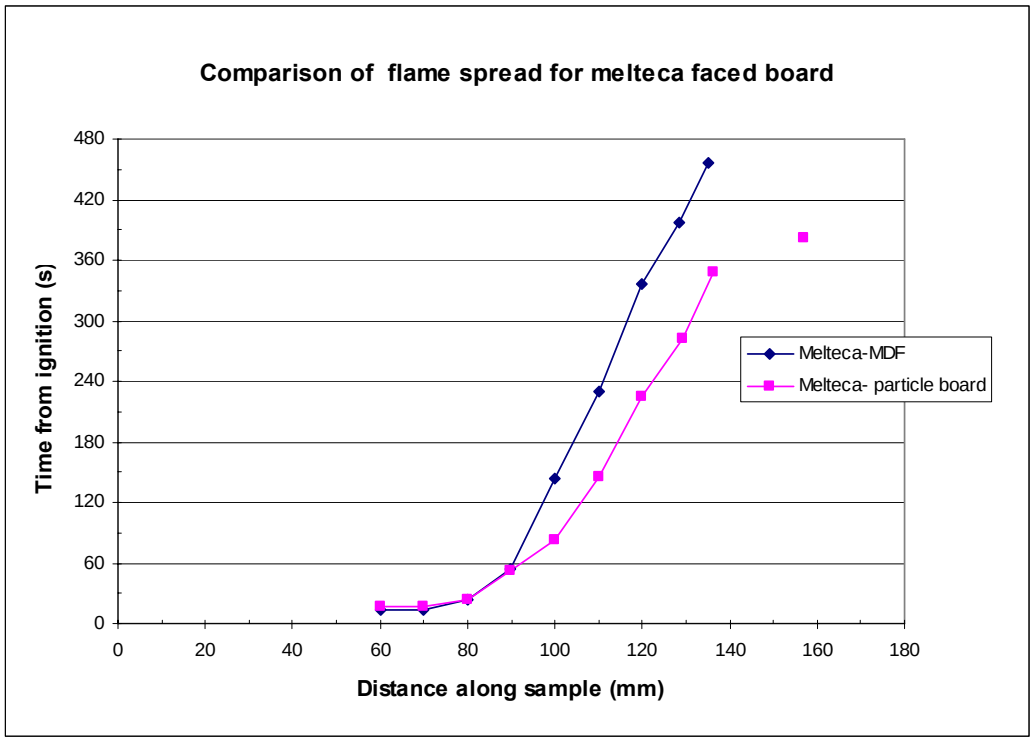



**Figure 94: Flame spread of Melteca faced boards in RIFT**

The difference between the two board types is greater than that of the substrate alone, indicating that the surface material is having a greater effect, as seen in Figure 95, where the time to a point on the sample for Melteca faced boards (MDF and particle board substrate) and for the MDF and particle board (Pynefloor) alone. This could be a factor of the manufacturer of the boards, as the facing material was not controlled and the boards come from different manufacturers.

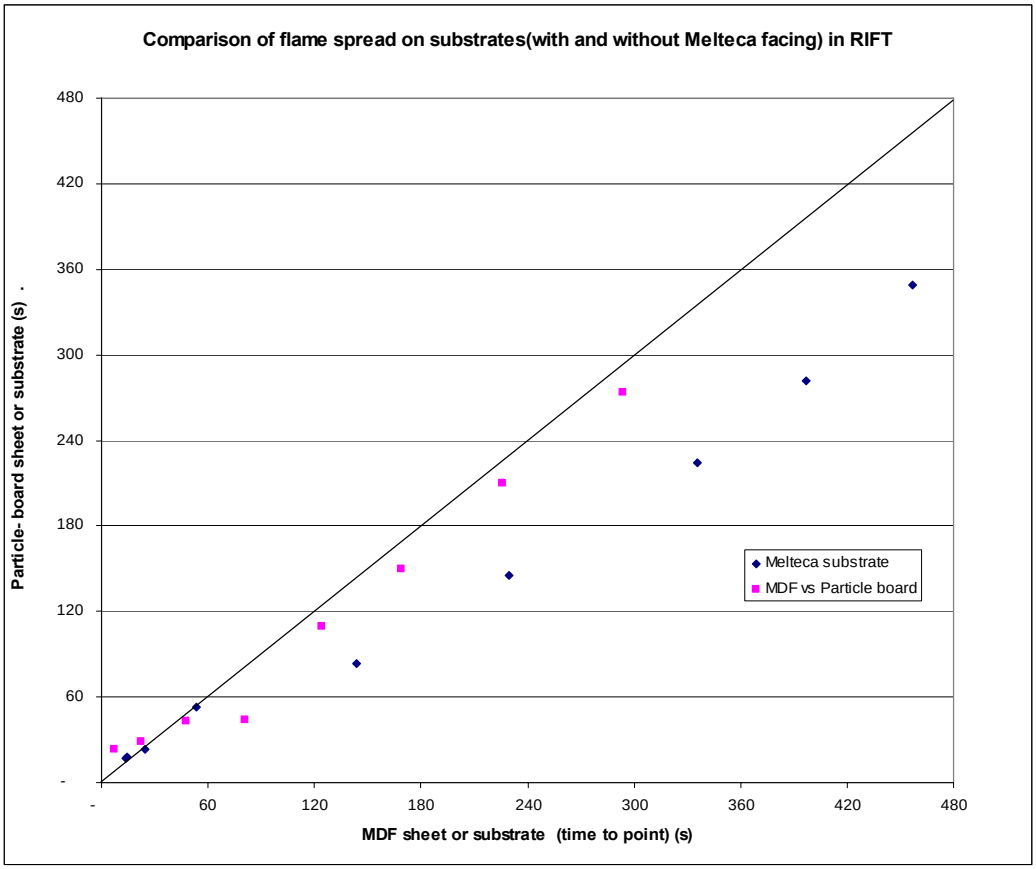



**Figure 95: Comparison of flame spread time to point for MDF vs. particle board, with and without Melteca facing in RIFT**

The erratic nature of the burning behaviour gives inconsistent results for the flame spread measurements. The correlation shows a large scatter (Figure 96 and Figure 97), with the Melteca- particle board being noticeably worse.

The greater sample size and resolution of the LIFT gives a better correlation than the RIFT for the same material. The data scatter in the RIFT results makes it more difficult to obtain accurate and consistent results for the flame spread correlation for Melteca faced boards.

Tests with the Melteca faced boards without preheating gave no useable result – there was no correlation of the data. Figure 98 shows the results for Melteca-MDF, where the data fit uses the measured value for the minimum ignition flux, and an estimated fit to the data and should be treated with caution. A mathematical fit to the data shows the slope of the best fit line being in the opposite direction.

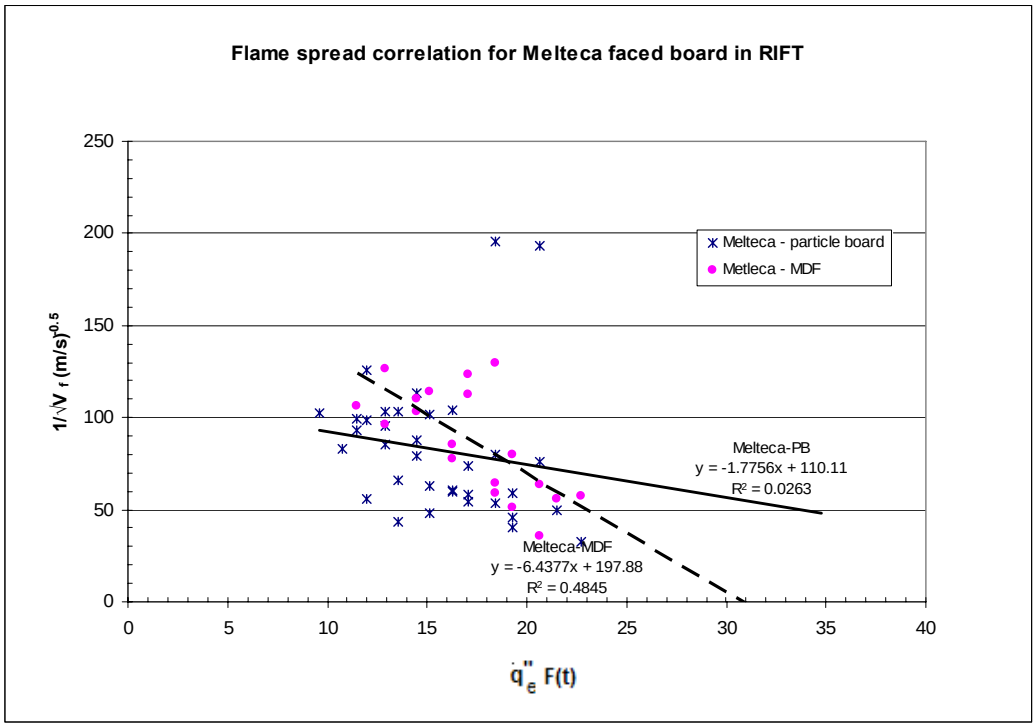



**Figure 96: Flame spread correlation for Melteca faced board in RIFT**

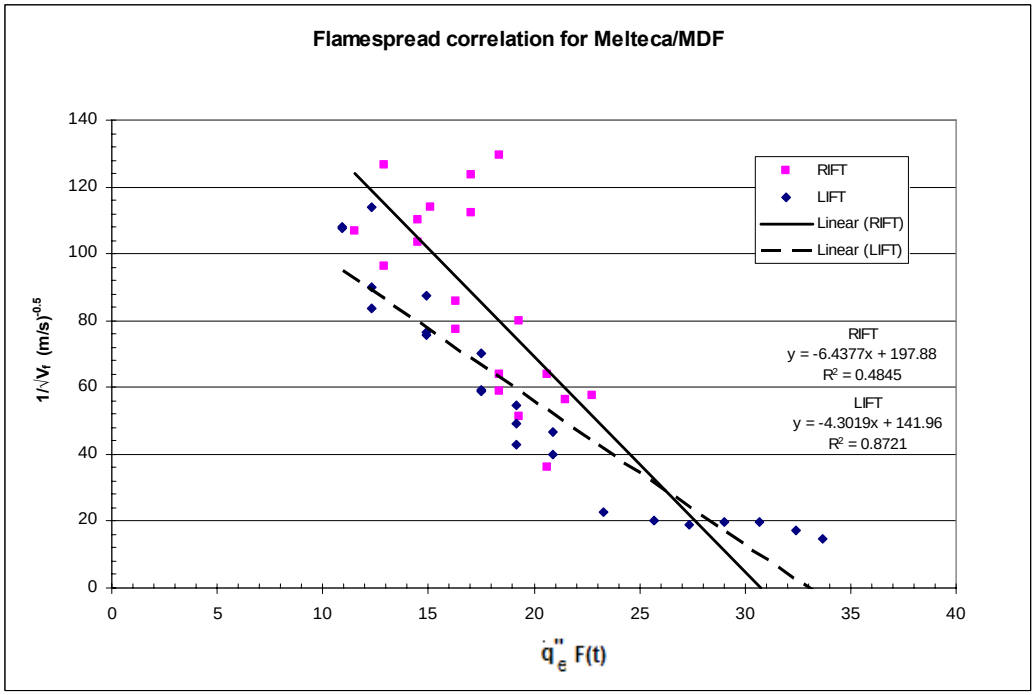



**Figure 97: Flame spread correlation for Melteca/ MDF**

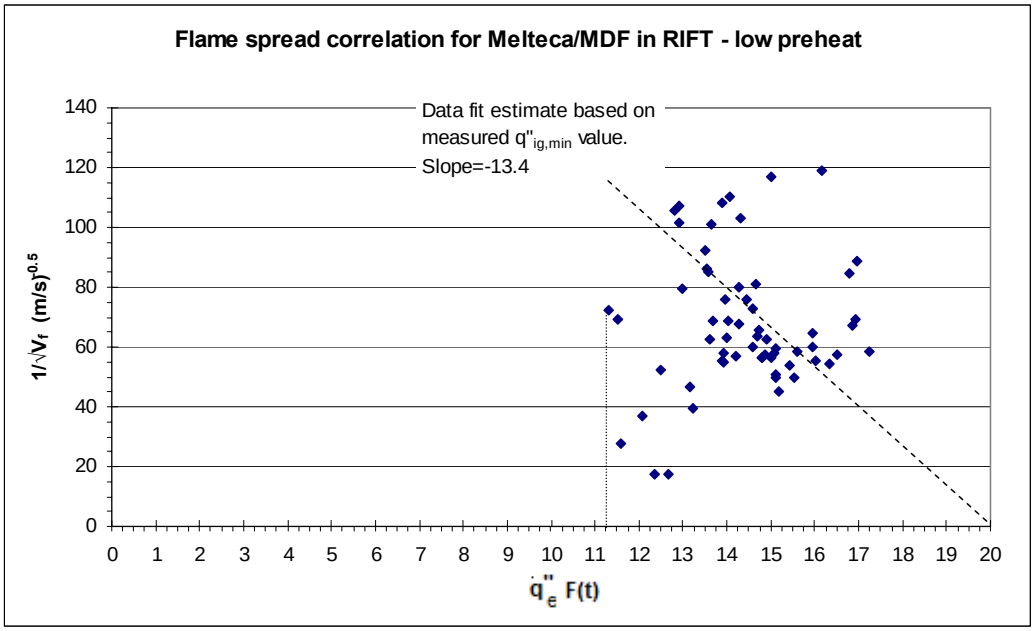



**Figure 98: Flame spread correlation for Melteca-MDF with a low preheating period**

*Flame spread of Melteca faced boards in LIFT*

The heat flux profile used in the LIFT test of Melteca- MDF is shown in Figure 99.

The flame spread results for Melteca-MDF (Figure 97 and Figure 100) shows less data scatter than the same material in the RIFT. This is due to the larger scale of the LIFT test, making the variation due to the burning behaviour of the facing material less significant.

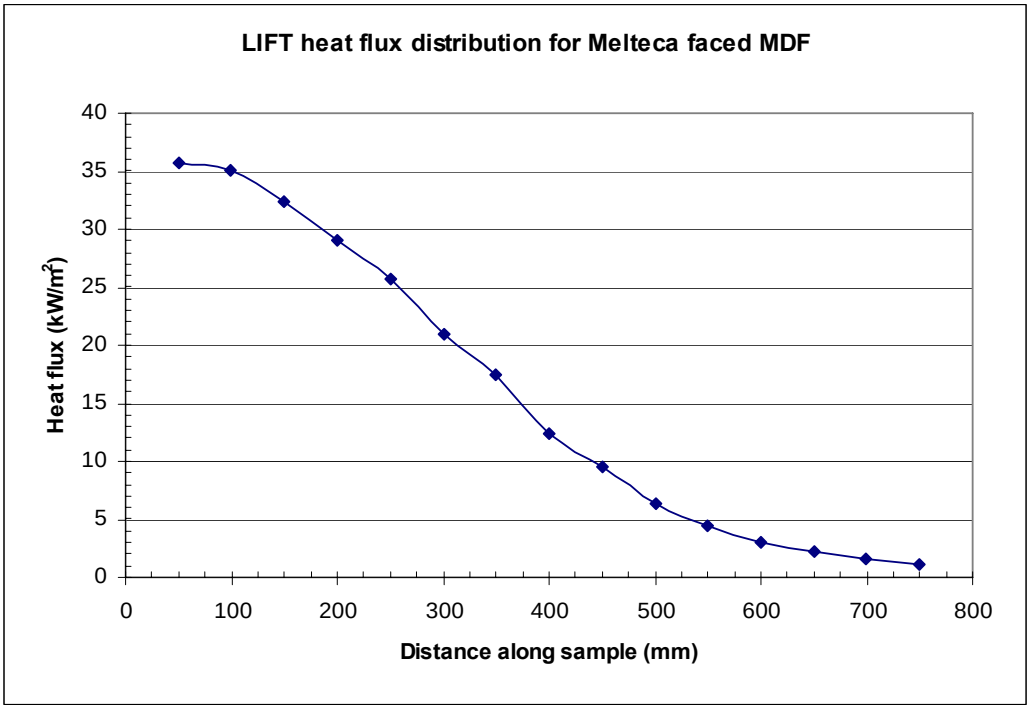



**Figure 99: LIFT heat flux profile for Melteca faced MDF flame spread test**

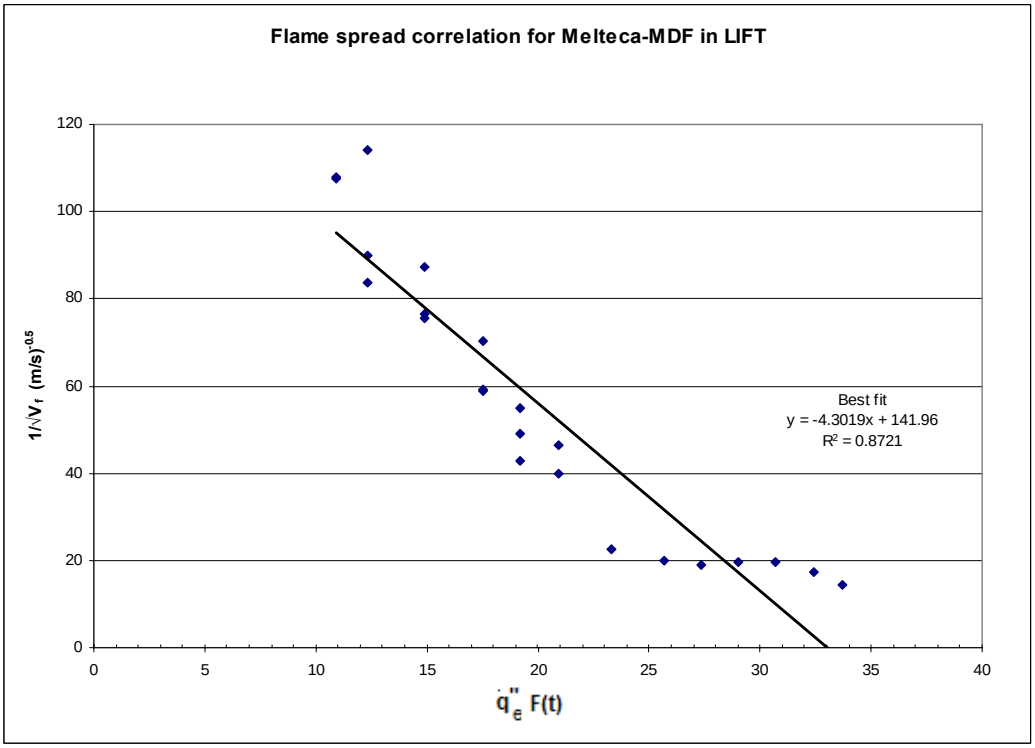



**Figure 100: Flame spread correlation for Melteca-MDF in LIFT**

# 9 Material test results for natural timbers

Natural timbers showed greater variation in the results between tests of identical materials than for manufactured boards, due to the greater variation in the material from the grain, knots or other features in the timber. The flame spread rates along the sample are generally higher for natural timbers than for the manufactured boards.

## *9.1 New Zealand Beech*

### 9.1.1 Ignition of Beech

The time to ignition for New Zealand Beech is shown in Figure 101.which shows greater variation in the time to ignition, than the other timber products (e.g. particle board Figure 54 and Figure 55) especially at low flux levels,

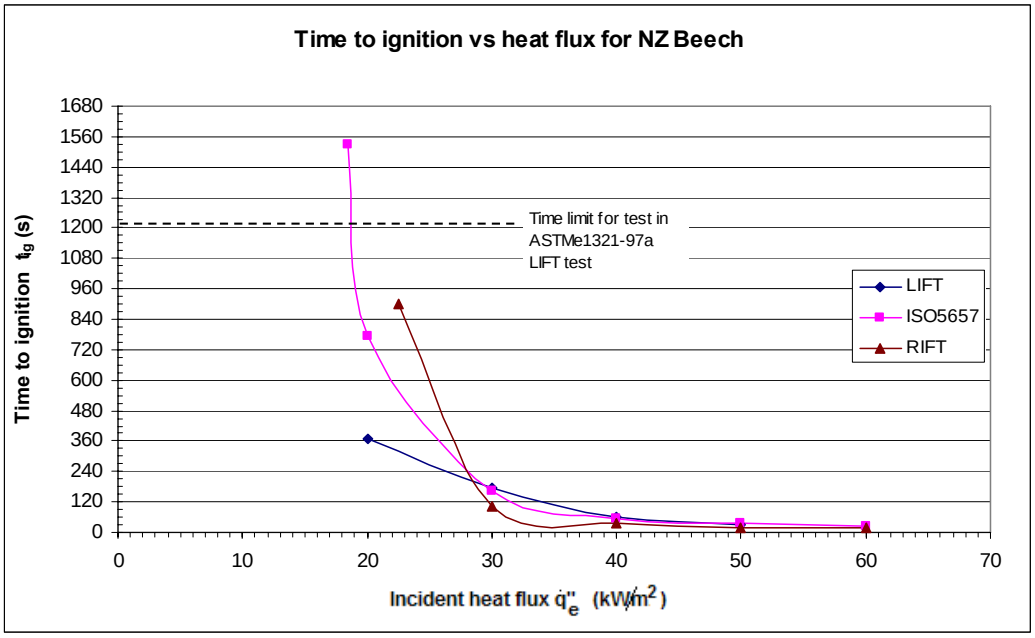



**Figure 101: Time to ignition vs. heat flux for NZ Beech**

The ignition parameter from ASTM E 1321-97a is shown below in Figure 102. While the ignition parameter results for the ISO 5657 and LIFT tests were similar at 0.050 $s^{0.5}$ for the ISO 5657 results, and 0.053 $s^{0.5}$ for the LIFT, the RIFT showed a wide

variation, due to the higher minimum ignition flux and shorter times to ignition than produced by the other methods.

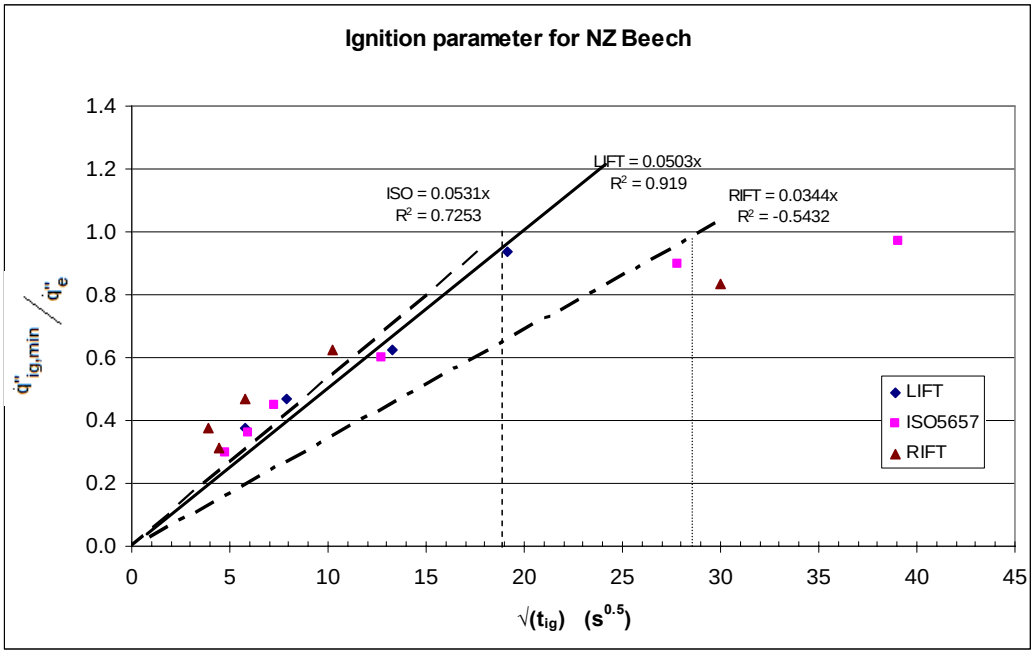



**Figure 102: Ignition parameter for Beech**

The ISO 5657 and LIFT gave similar results for the critical ignition flux (Figure 103) and there is greater variation for the critical flux calculated from the RIFT ignition test.

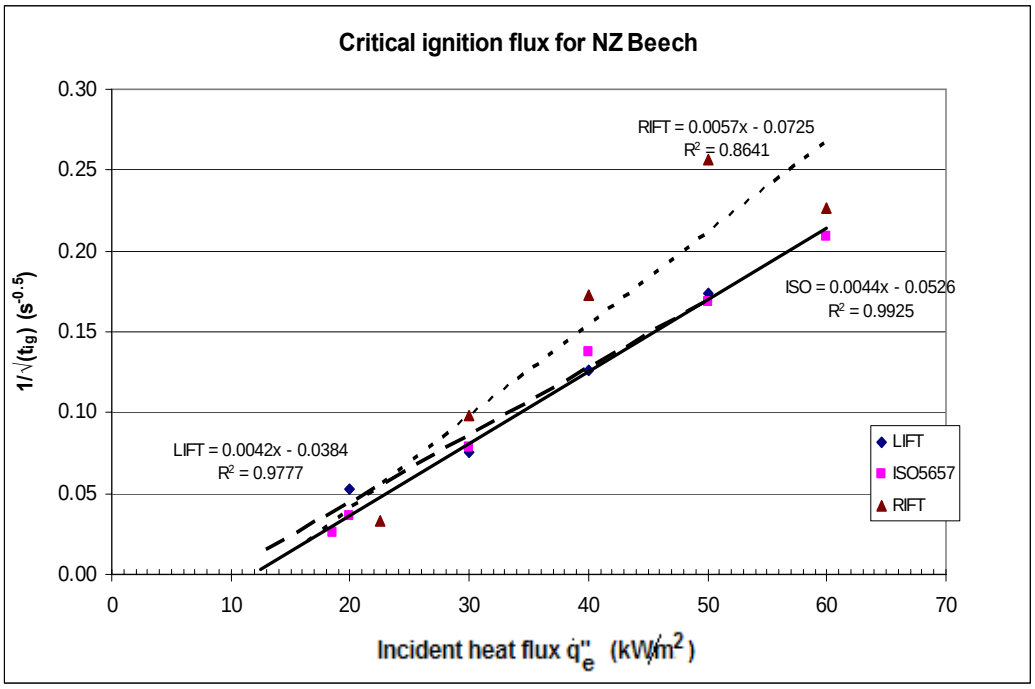



**Figure 103: Critical ignition flux for NZ Beech**

### 9.1.2 Flame spread of Beech

*Flame spread of NZ Beech in the RIFT*

The flame spread showed vide variations between runs in the RIFT, whether or not it was preheated prior to ignition (Figure 104 and Figure 105) and the flame spread in the RIFT was less consistent than in the LIFT (Figure 108). The low preheat time was 55 seconds, against a full preheat time for the RIFT of 844 seconds, and 395 seconds for the LIFT, using the ignition data from the LIFT ignition tests for this material.

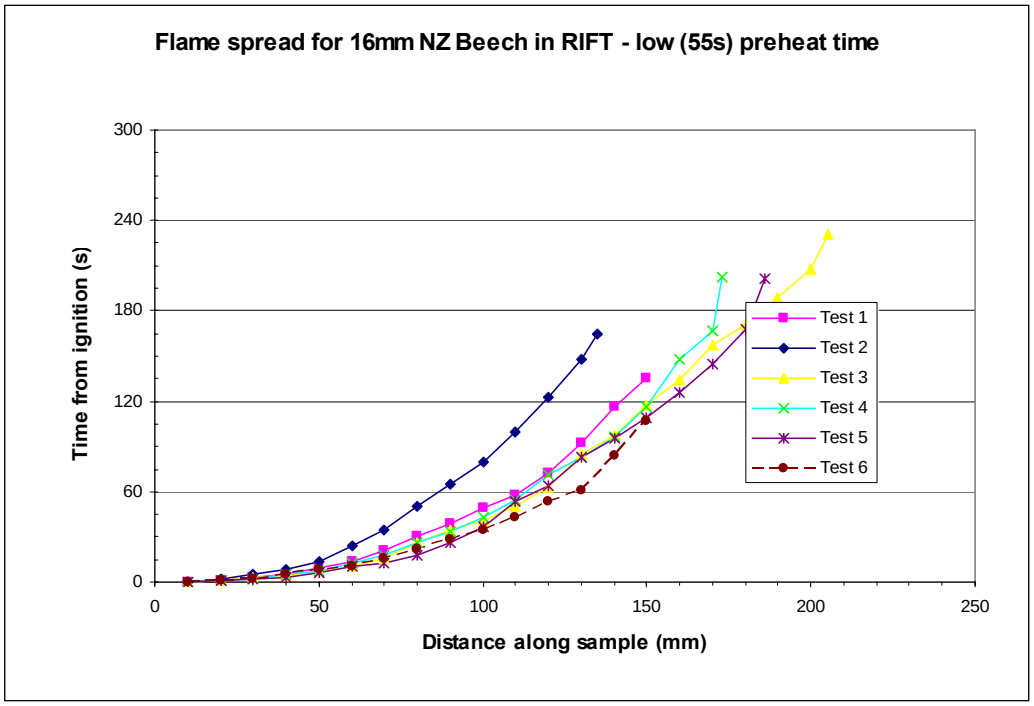



**Figure 104: Flame spread of Beech in RIFT with 55 second preheating period**

The extent of flame spread is less if the material is not preheated and hence the experimental value for the minimum heat flux for flame spread is higher than for a fully preheated sample. As can be seen from time to reach each point on the sample in Figure 104, the rate of flame spread was very rapid in comparison to the other materials tested, indicating that the flame spread was faster than the surface of the material could reach the minimum ignition temperature, hence the extent of flame spread is less when the material has not been preheated fully prior to ignition.

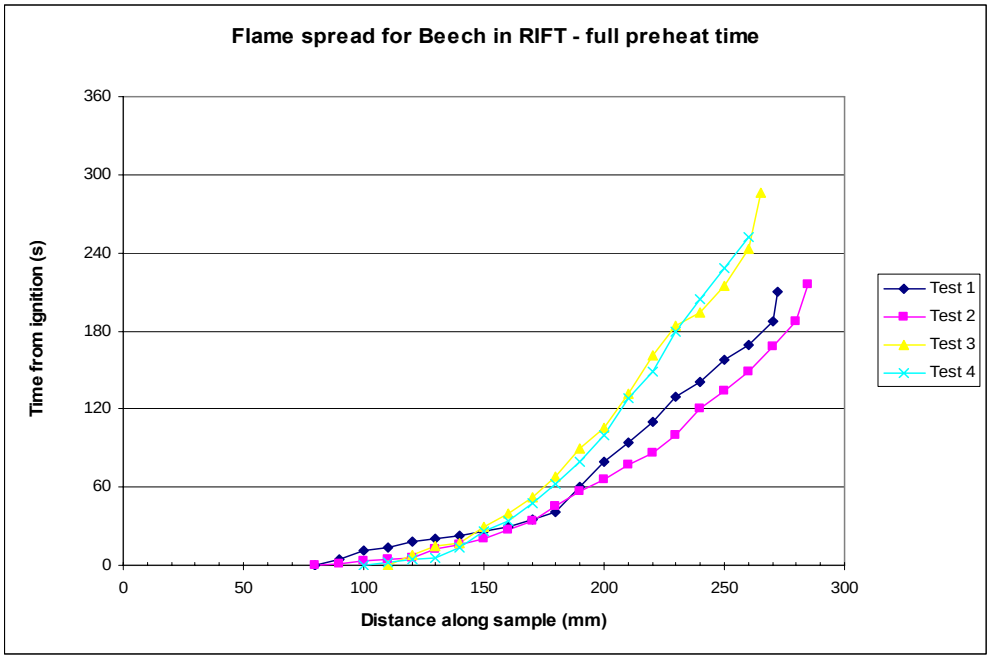



**Figure 105: Flame spread for Beech in RIFT with full preheat**

The effect that the ignition data has on the flame correlation is shown in Figure 106, where the same flame velocity measurements are used, but with the *"b"* value and thermal equilibrium time *"$t^*$"* from the ignition tests in the RIFT and ISO 5657 ignition apparatus.

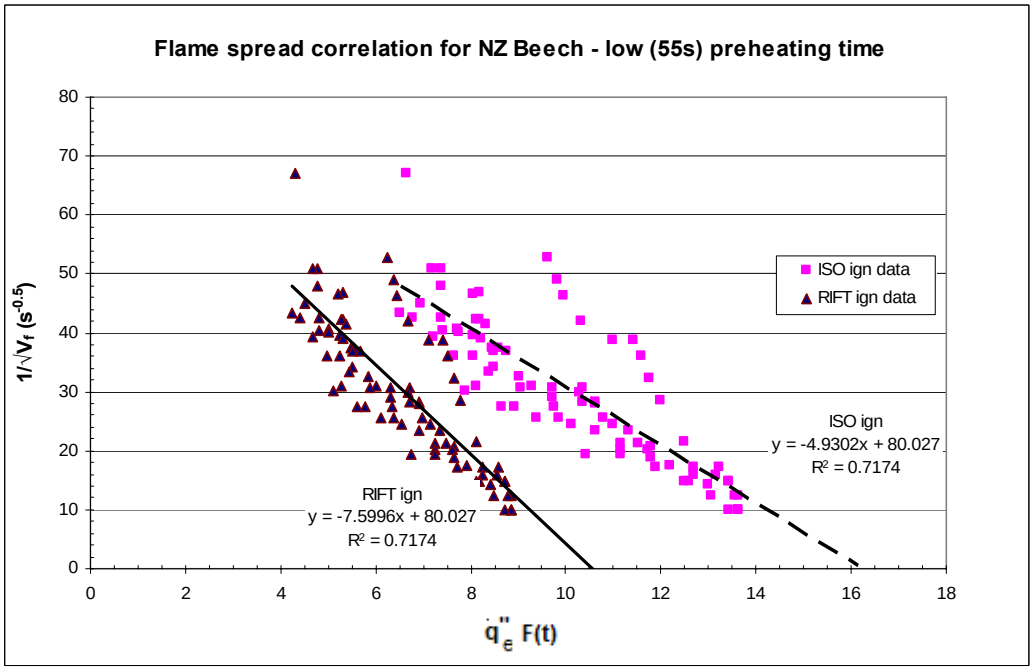



**Figure 106: Flame spread correlation for NZ Beech in RIFT - low preheat time**

The flame spread correlation for the RIFT with the full preheating period is compared with the LIFT in Figure 110.

*Flame spread of NZ Beech in the LIFT*

The heat flux profile used for the LIFT tests of NZ Beech is shown in Figure 107.

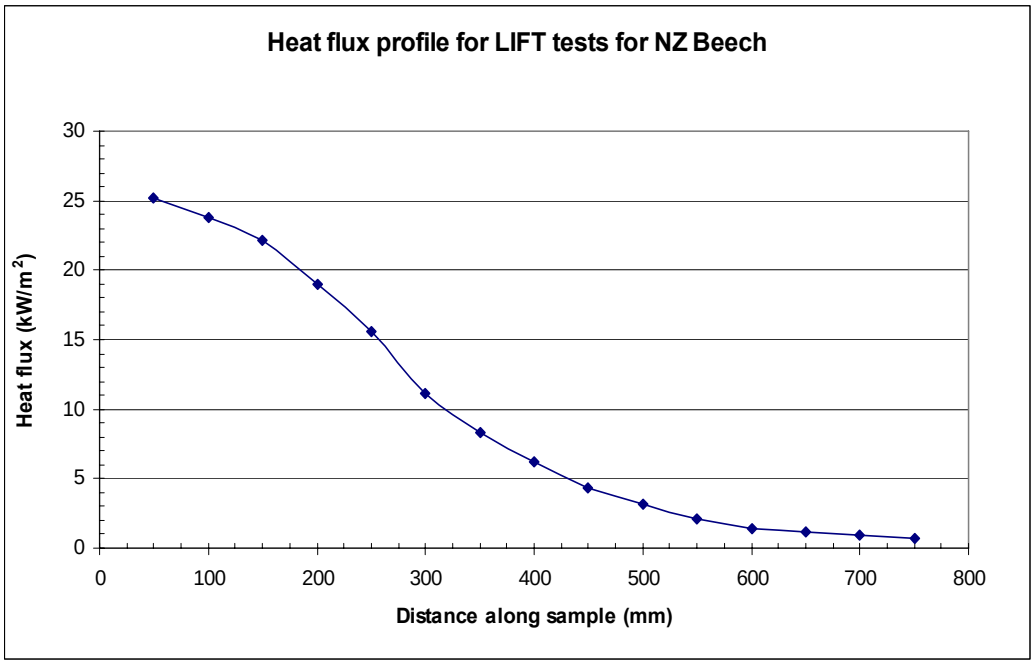



**Figure 107: Heat flux profile for LIFT tests for NZ Beech**

The flame spread along the sample (Figure 108) showed much less variation than for the same material in the RIFT (Figure 105).

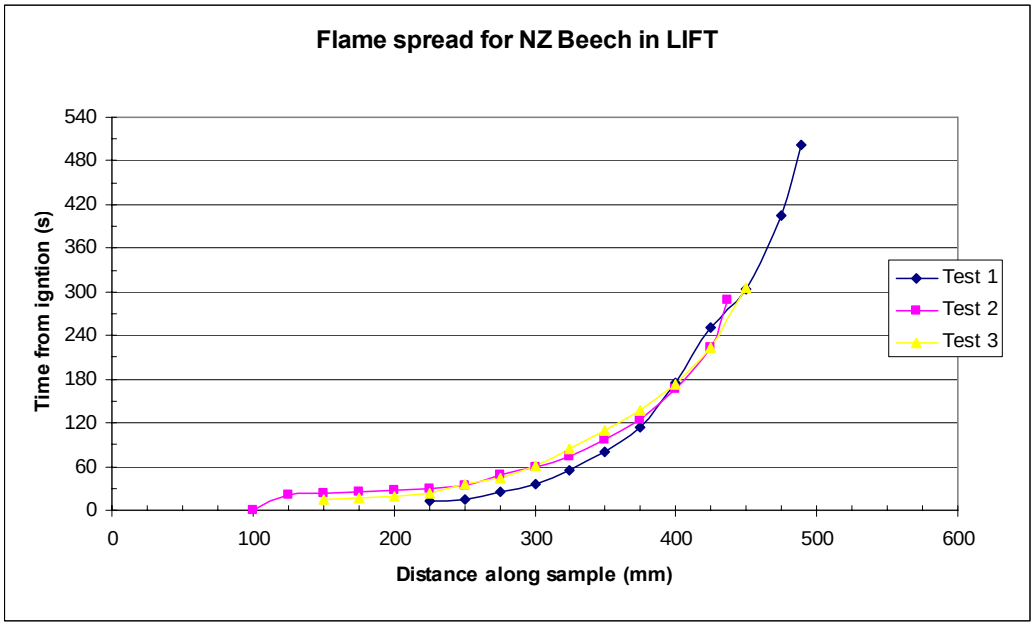



**Figure 108: Flame spread for NZ Beech in LIFT**

The resulting flame spread correlation, shown in Figure 109 shows some curvature in the fit of the data, indicating that the material may not have reached thermal equilibrium, despite being preheated to the time given by the ignition results.

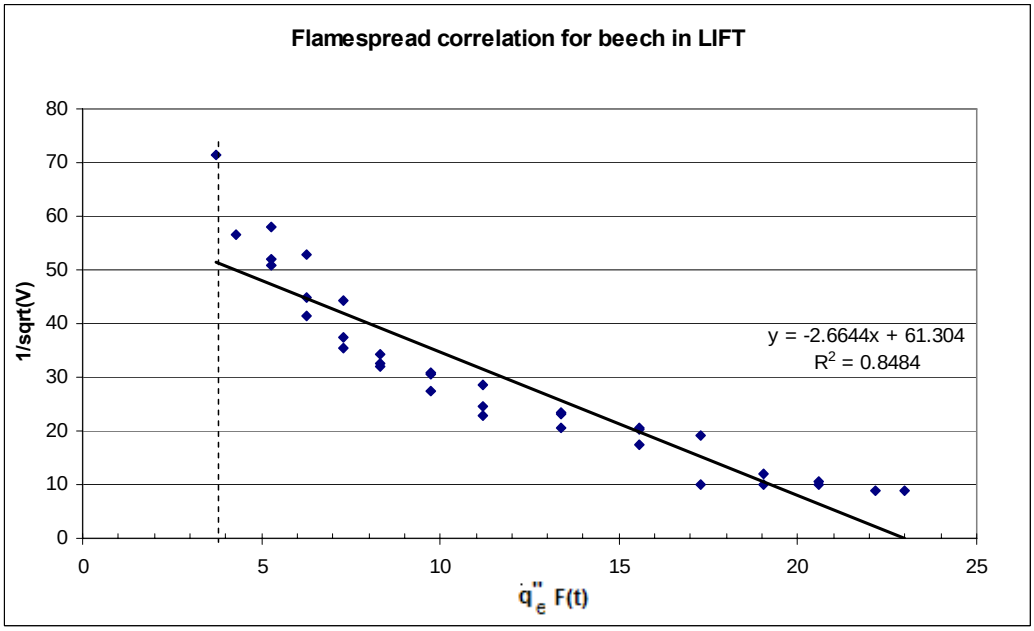



**Figure 109: Flame spread correlation for NZ Beech in LIFT**

The RIFT and LIFT gave similar results for the flame spread correlation (Figure 110) at 74.8 for the RIFT and 58.3 for the LIFT, although the RIFT has more scatter in the

data, shown by the lower $R^2$ value. The results for the correlated values for the minimum heat flux for flame spread and the minimum ignition flux are similar with both methods.

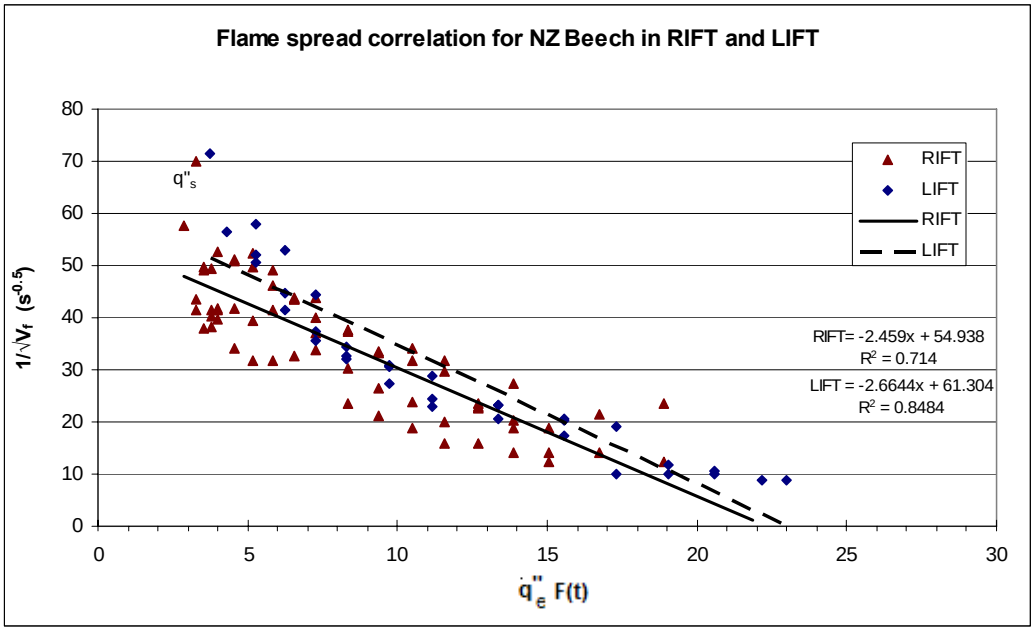



**Figure 110: Flame spread correlation of Beech in RIFT and LIFT.**

## *9.2 Macrocarpa*

### 9.2.1 Ignition of Macrocarpa

The three ignition test methods produced similar results for Macrocarpa (Figure 111), with the LIFT having longer times to ignition at low heat flux levels.

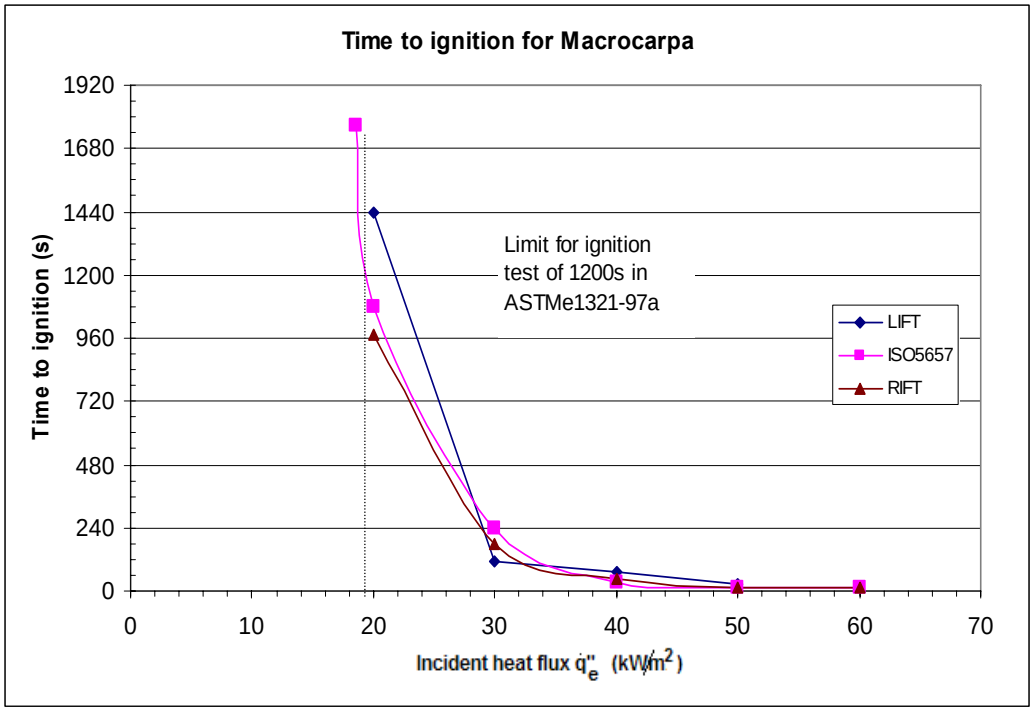



**Figure 111: Time to ignition for Macrocarpa**

The ignition parameter (Figure 112) and the critical ignition flux (Figure 113) show much more scatter in the data than the manufactured boards, such as MDF (Figure 46 and Figure 45) or particle board (Figure 56 - Figure 59).

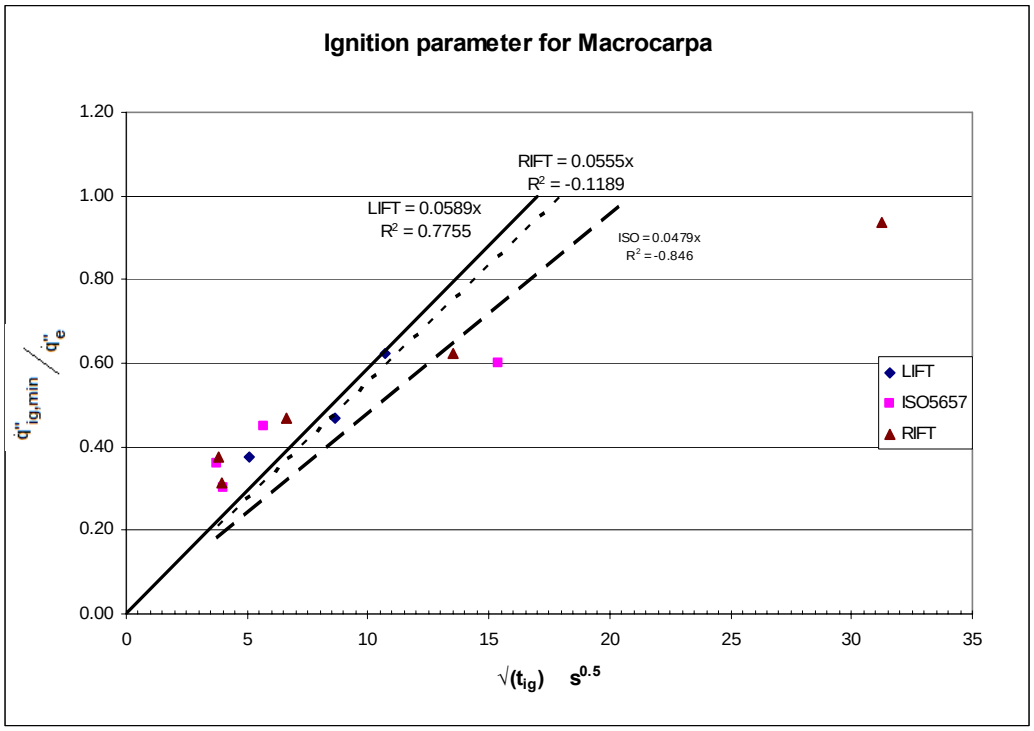



**Figure 112: Ignition parameter for Macrocarpa**

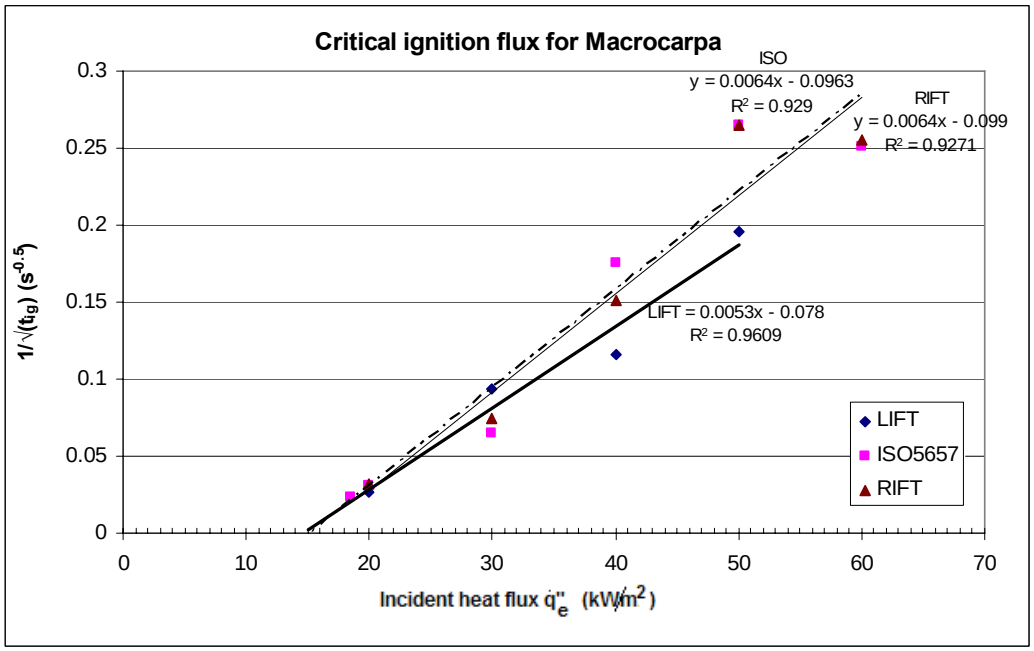



**Figure 113: Critical heat flux for Macrocarpa**

### 9.2.2 Flame spread of Macrocarpa

The resinous streaks in Macrocarpa can make the flame spread erratic, as the flame front can tend to follow a resin streak on the face of the timber, rather than spreading evenly over the face of the material. This gives more erratic flame spread than for a more consistent material, seen in the variation of the flame spread results between runs in Figure 115 and Figure 117.

The preheating time was 40 seconds for the low preheating tests, and 436 seconds for a full preheating time in the RIFT, based on the ISO 5657 ignition tests, and 288 seconds for the LIFT ignition tests

*Flame spread in RIFT*

The flame spread for Macrocarpa showed wide variation between tests of the same material under the same conditions (Figure 114 and Figure 115), particularly towards the end of the sample.

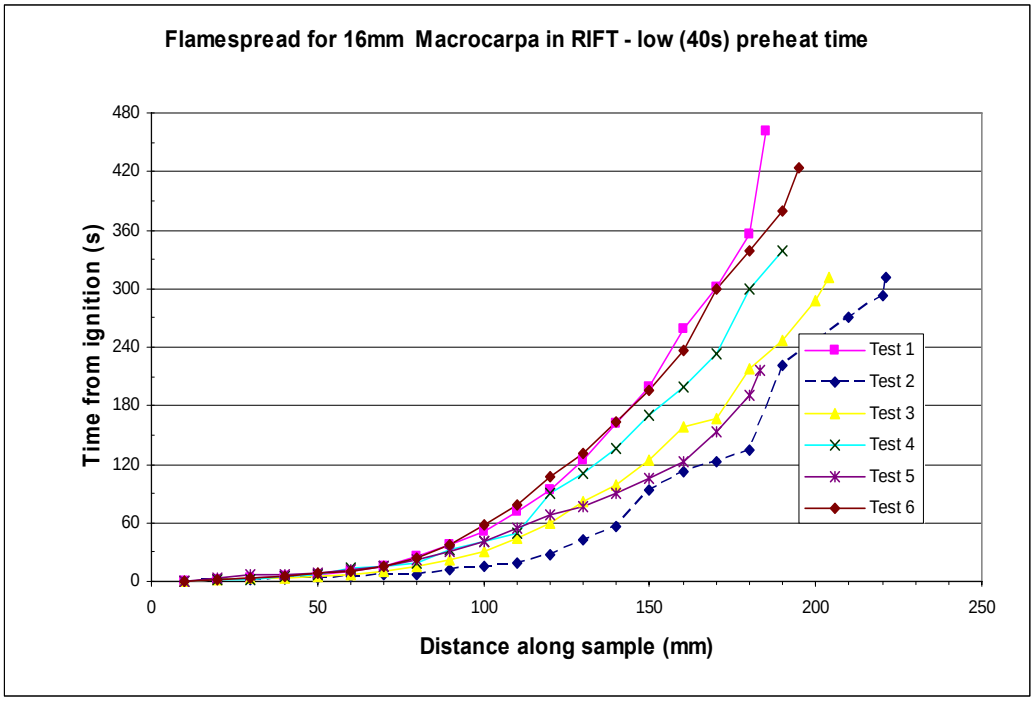



**Figure 114: Flame spread of Macrocarpa in RIFT with low (40s) preheat time**

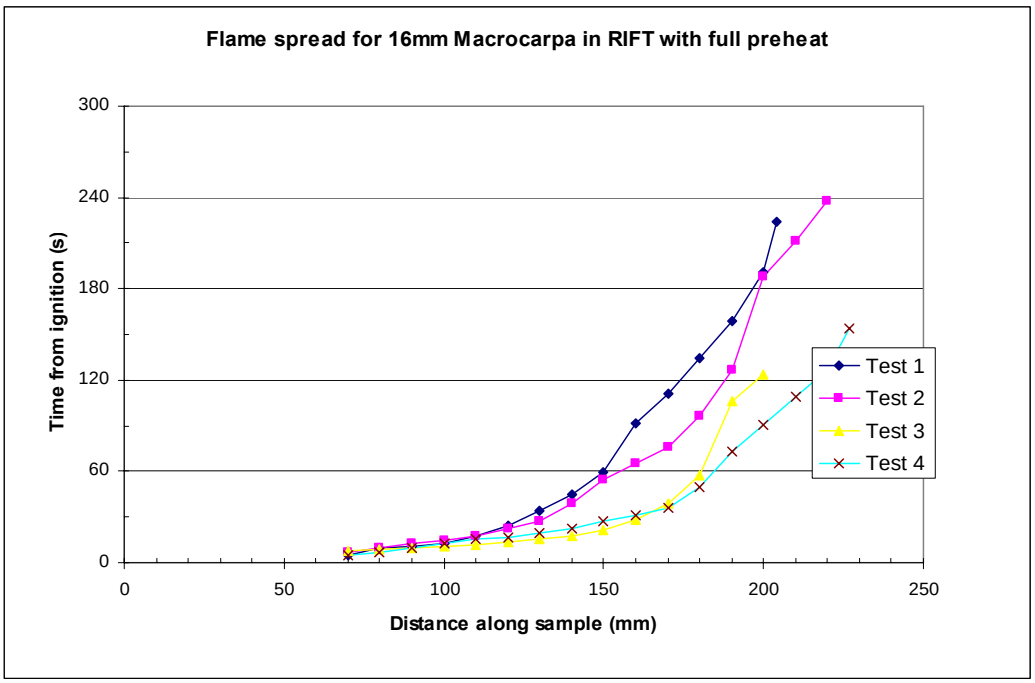



**Figure 115: Flame spread of Macrocarpa in RIFT – full preheat of 436 seconds**

The resulting flame spread correlation for the RIFT results shows a lot of data scatter and the linear fit is a relatively poor match (Figure 116). The fit of the data, shown by the $R^2$ values seen on the chart, improves with preheating the sample prior to ignition, but is still poor.

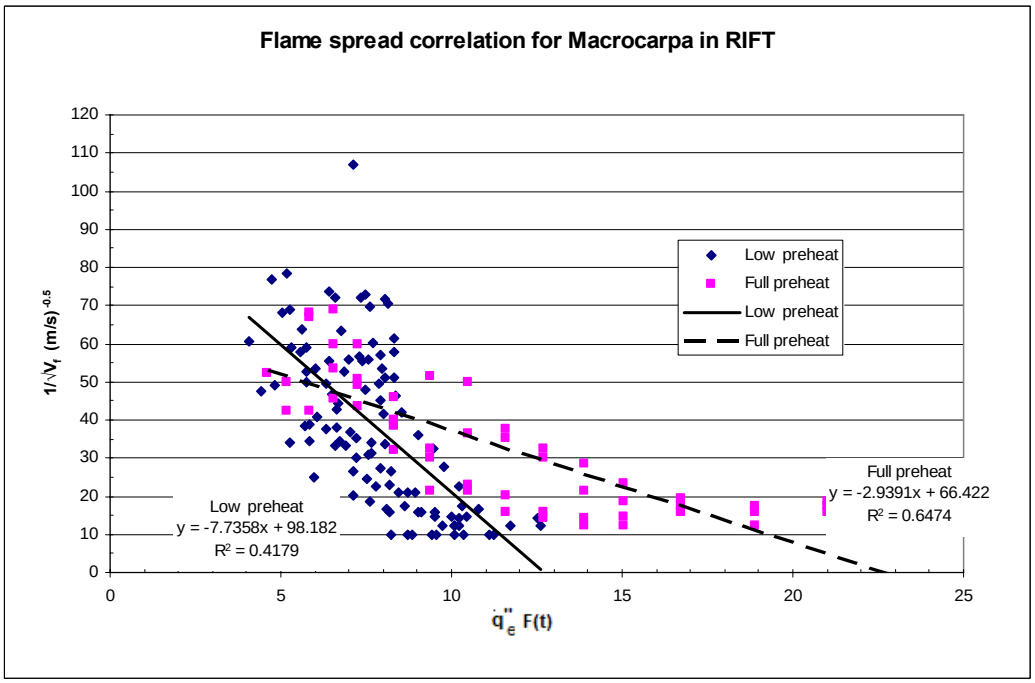



**Figure 116: Flame spread correlation for Macrocarpa in RIFT**

*Flame spread of Macrocarpa in LIFT*

The flame spread for Macrocarpa in the LIFT showed similar variation between tests to the samples in the RIFT.

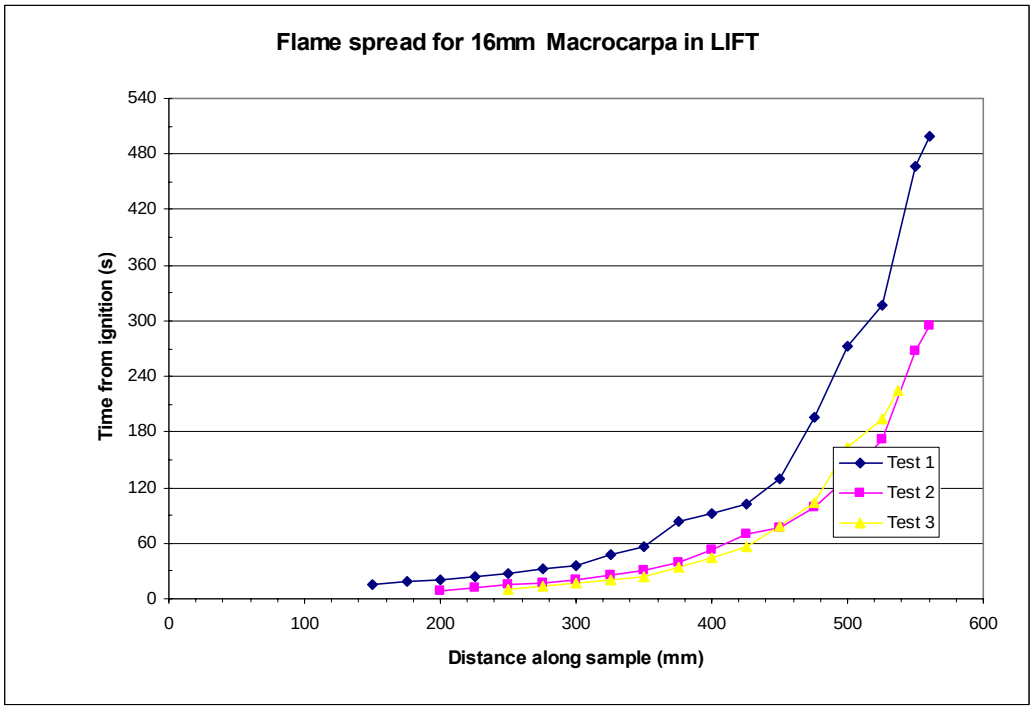



**Figure 117: Flame spread for Macrocarpa in LIFT**

The curve to the LIFT results in the flame spread correlation (Figure 118) indicates that the material was not preheated sufficiently, based on the work by Quintiere (1981), despite the preheating time coming from the LIFT ignition results.

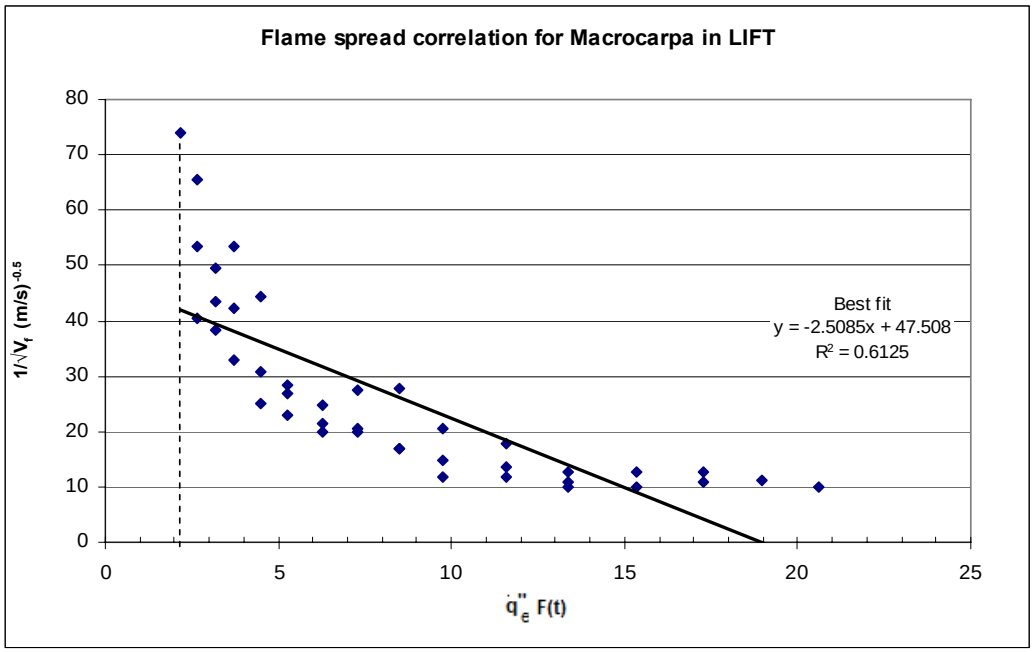



**Figure 118: Flame spread correlation for Macrocarpa in LIFT**

The comparison of the RIFT and LIFT results (Figure 119) for the flame spread correlation shows the RIFT gives a higher value for the correlated value of the minimum ignition flux $\dot{q}''_{ig,\min}$ although the flame spread modulus C (the slope of the best fit line) is similar. In this case, the value of the minimum flux for spread $\dot{q}''_{s}$ is higher for the RIFT than the LIFT.

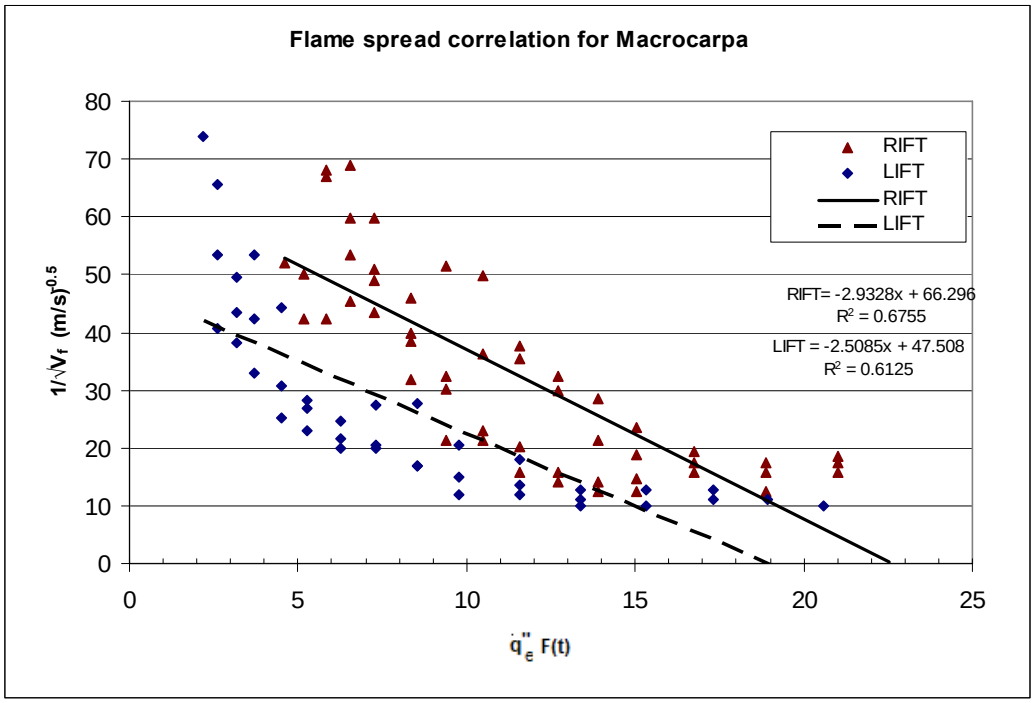



**Figure 119: Flame spread correlation for Macrocarpa**

## *9.3 Radiata Pine*

### 9.3.1 Ignition of Radiata Pine

The time to ignition for the three ignition test methods is given in Figure 120, where the ISO 5657 and RIFT gave similar results. As can be seen in the results, in some cases, the material still ignited after the limiting ignition test period. .During the course of the test, the material noticeably charred over the long test intervals, with some surface cracking. Localised surface hot spots formed, where an area around 2cm across would be glowing, when the rest of the sample showed no signs of heating.

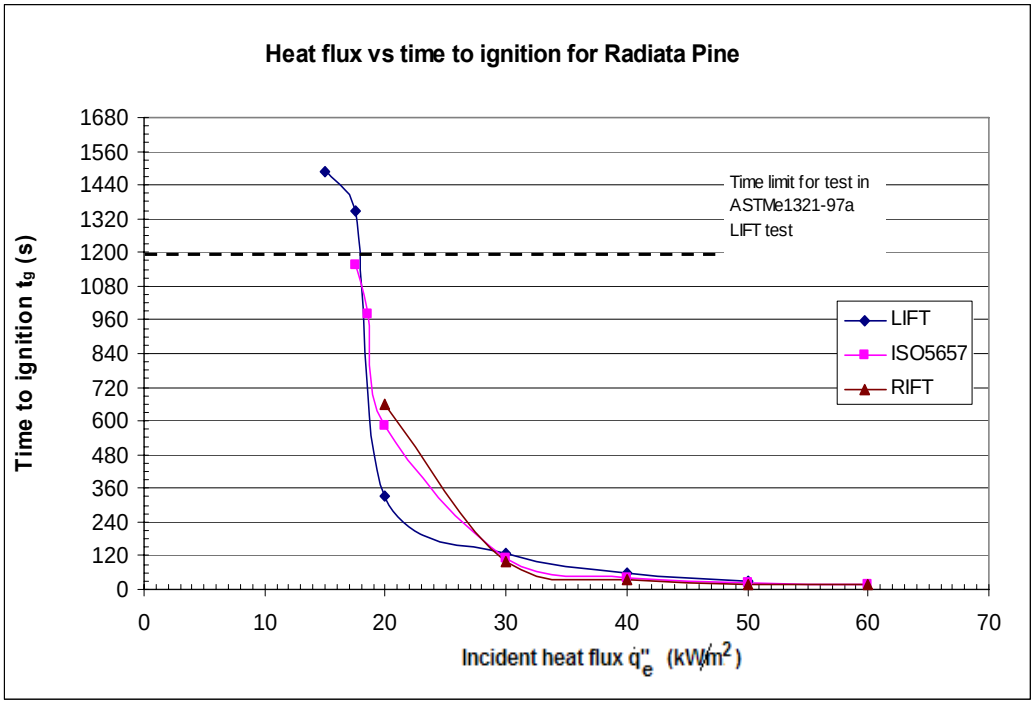



**Figure 120: Time to ignition of Radiata Pine**

The three methods gave similar results for the critical ignition flux (Figure 121).

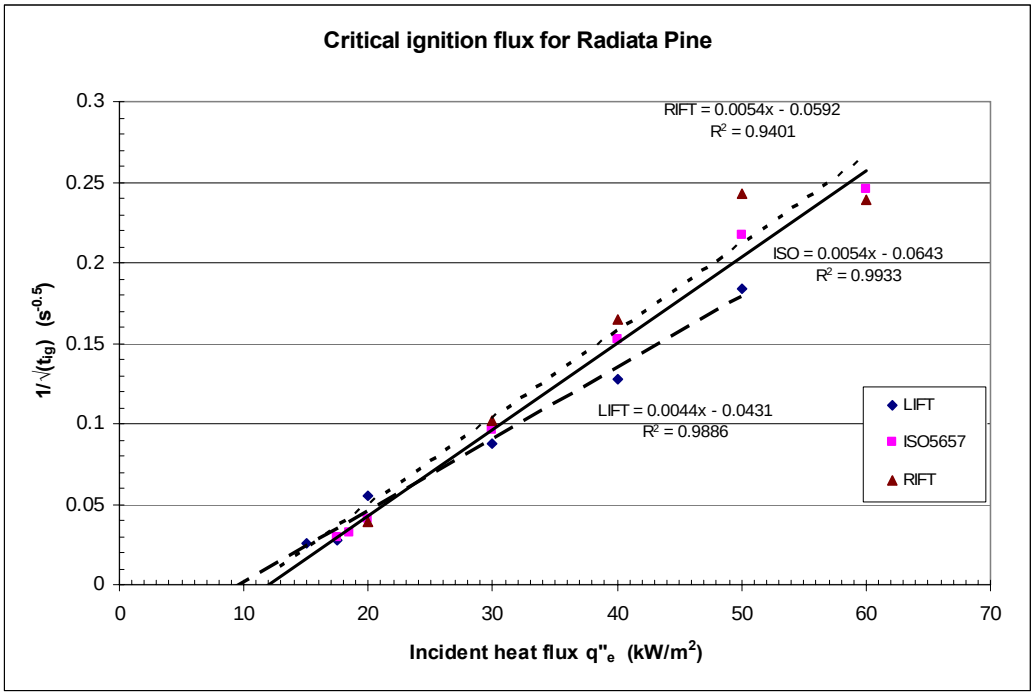



**Figure 121: Critical ignition flux for Radiata Pine**

The ignition parameter chart (Figure 122) shows that the three different methods gave widely different values for the equilibrium time $t^*$ despite eliminating the values for $\dot{q}''_{ig,\min} / \dot{q}''_e < 0.8$ for calculating the data fit.

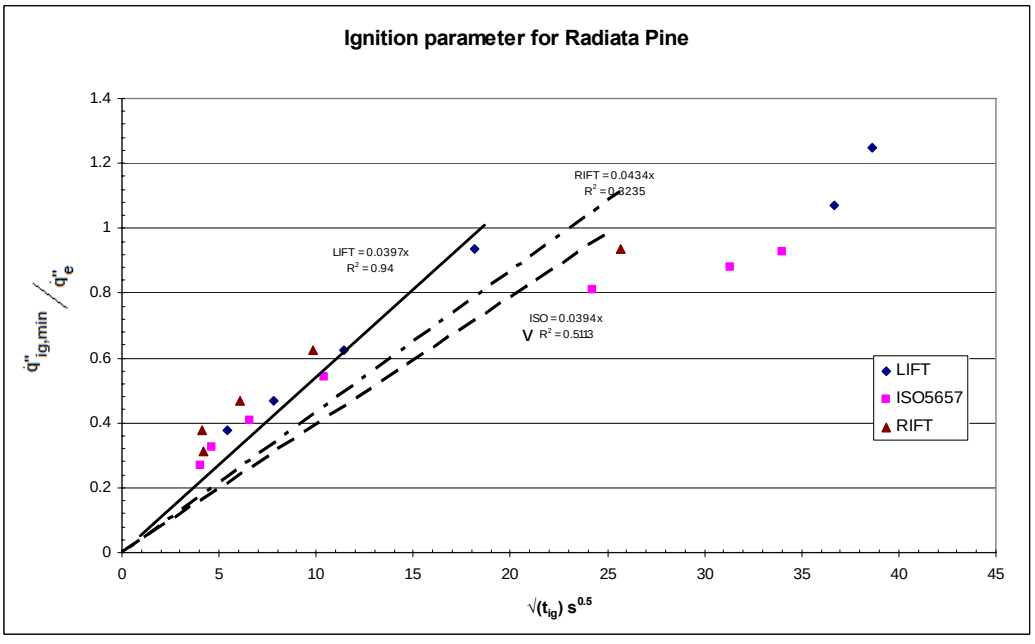



**Figure 122: Ignition parameter for Radiata Pine**

### 9.3.2 Flame spread of Radiata Pine

The low preheat time for the flame spread tests was 40 seconds. The full preheat time was 643 seconds in the RIFT and 341 seconds in the LIFT. Radiata Pine noticeably charred during the preheating period, and the area up to 180mm along the sample was difficult to ignite just by using the pilot flame.

*Flame spread of Radiata Pine in RIFT*

The flame spread along the Radiata Pine samples in the RIFT is shown in Figure 123 and Figure 124. The effect of preheating of the sample can be seen in Figure 125 - the preheated sample has a larger flame spread distance, with a lower time to reach each point on the sample, giving a higher flame front velocity.

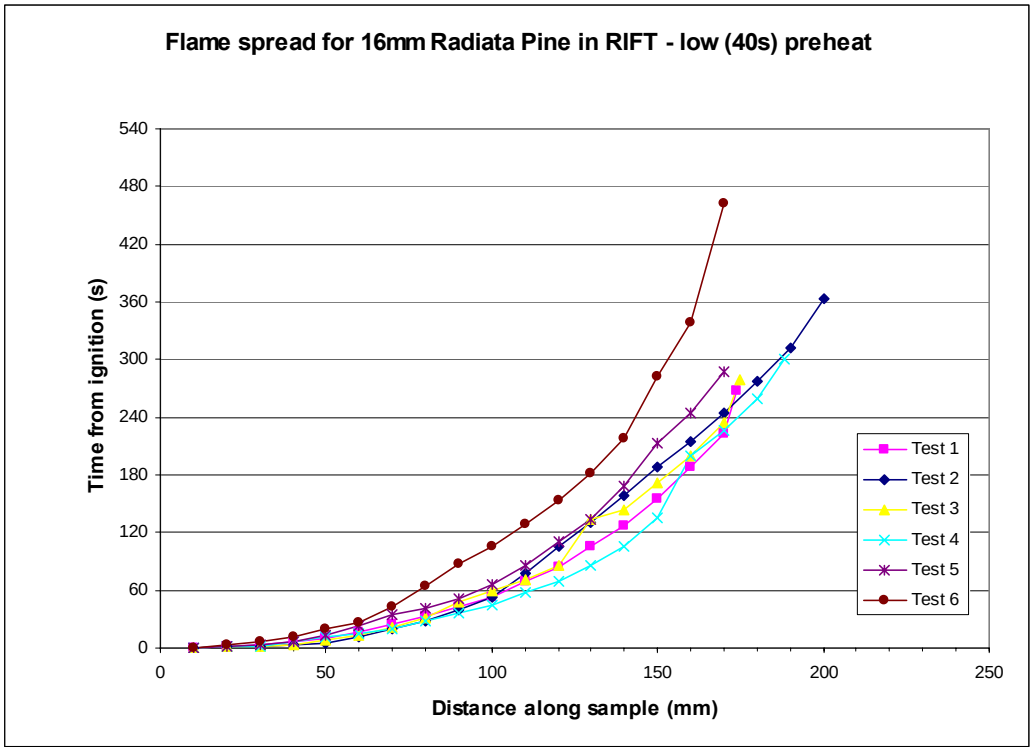



**Figure 123: Flame spread for Radiata Pine in RIFT – low (40s) preheat**

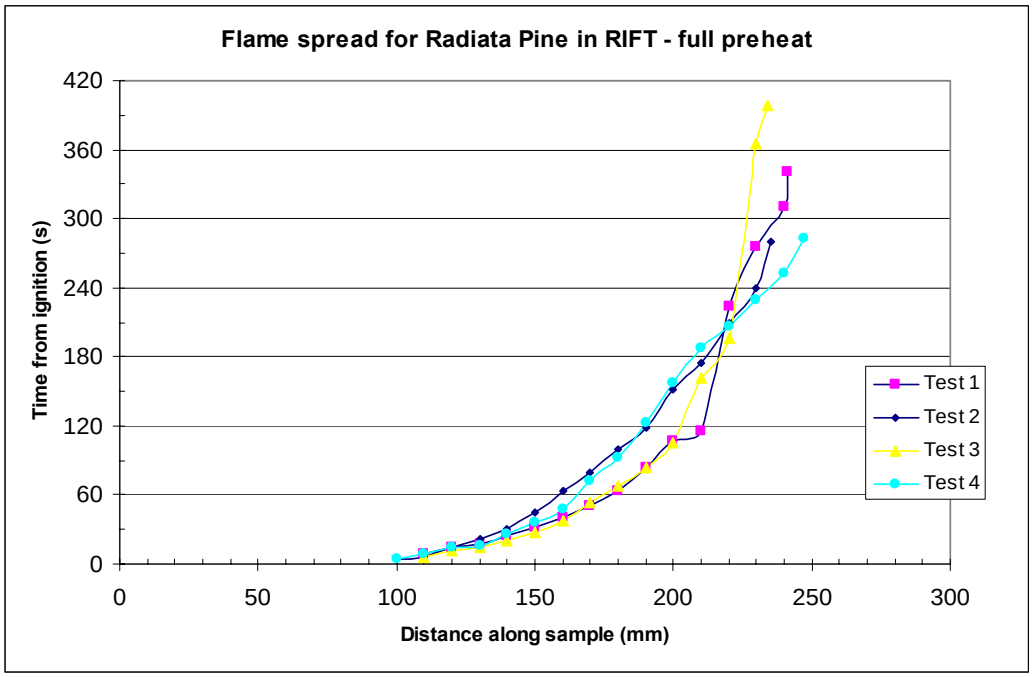



**Figure 124: Flame spread for Radiata Pine in RIFT - full preheat**

The effect of preheating on the flame spread can be seen in Figure 125, where preheating increases the flame spread rate.

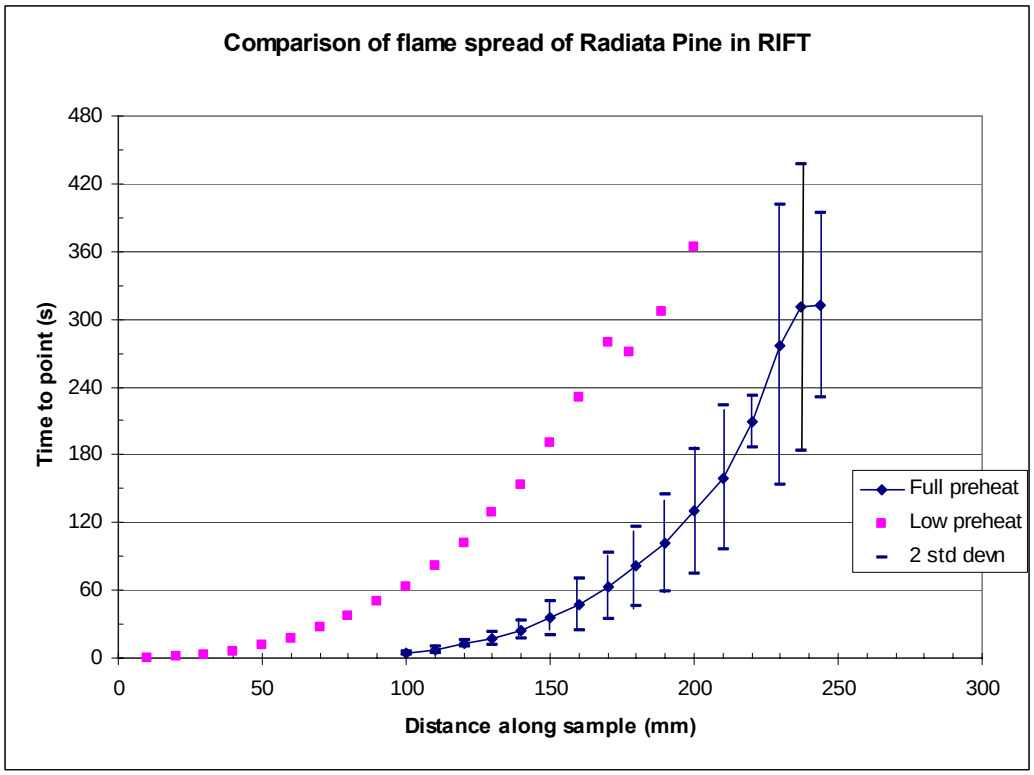



**Figure 125: Comparison of flame spread of Radiata Pine**

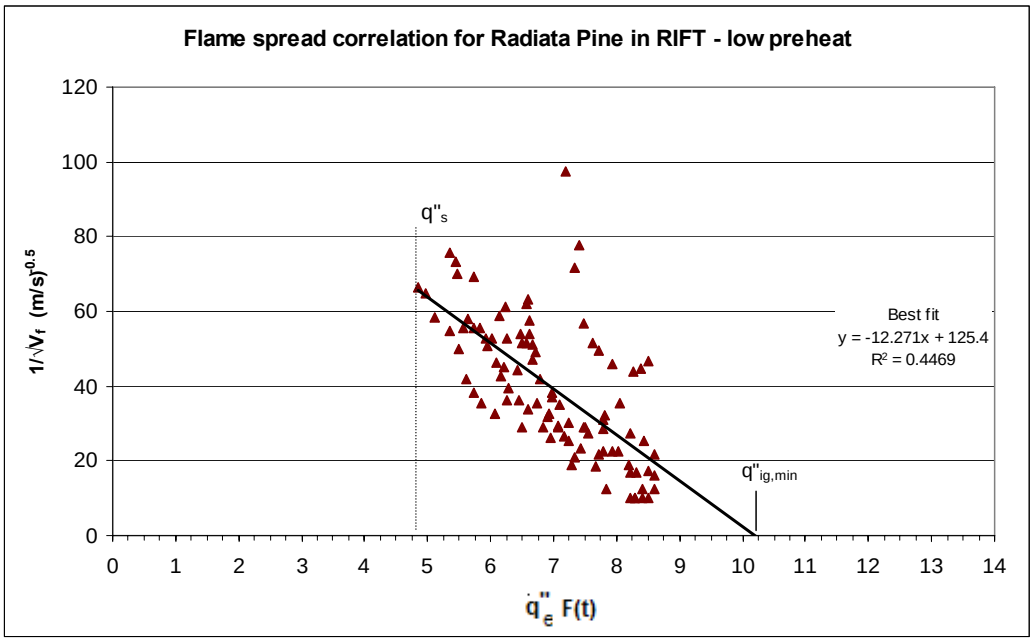



**Figure 126: Flame spread correlation for Radiata Pine in RIFT – low preheat time**

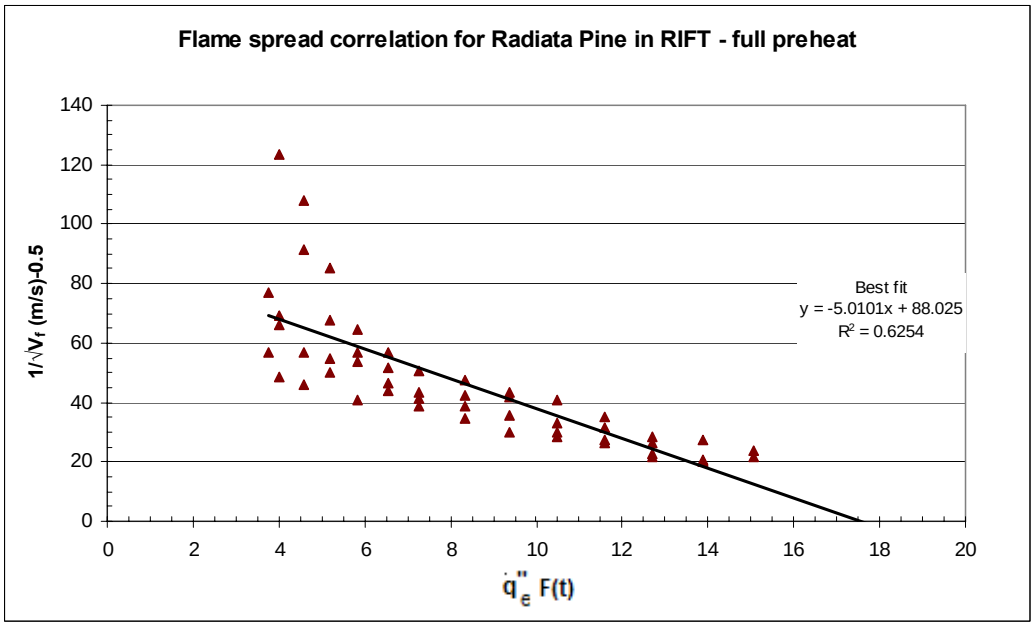



**Figure 127: Flame spread correlation for Radiata Pine in RIFT - full preheat**

*Flame spread for Radiata Pine in LIFT*

The heat flux distribution for the flame spread tests in the LIFT is the same as that for Rimu, shown in Figure 135.

The flame spread rate (Figure 128) for Radiata pine shows less variation than some of the other material tested, such as Macrocarpa (Figure 117) or Beech (Figure 108).

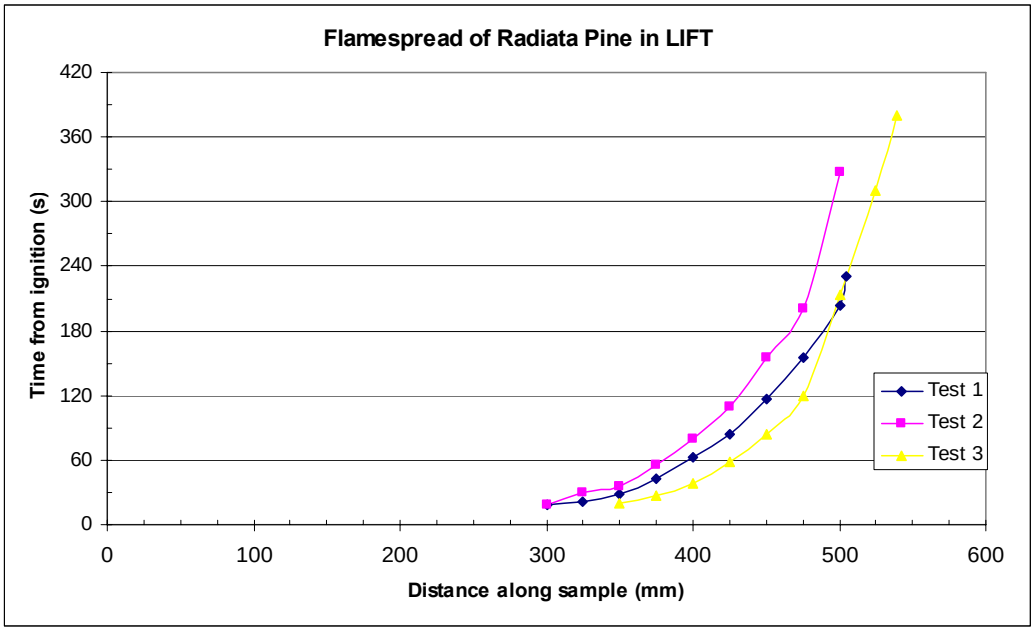



**Figure 128: Flame spread of Radiata Pine in LIFT**

The more consistent flame spread behaviour (when compared to macrocarpa) gives a more accurate correlation for the flame spread (Figure 127) with less scatter in the data.

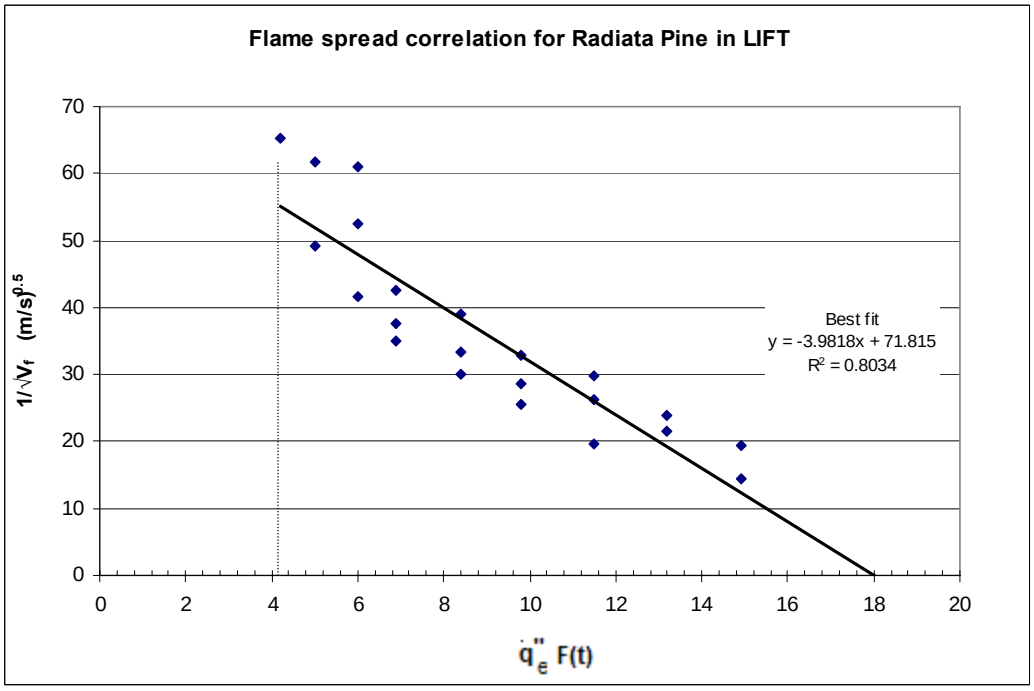



**Figure 129: Flame spread correlation for Radiata Pine in LIFT**

The RIFT gives a similar match for the flame spread correlation (Figure 130) but with more data scatter, shown by the lower $R^2$ value.

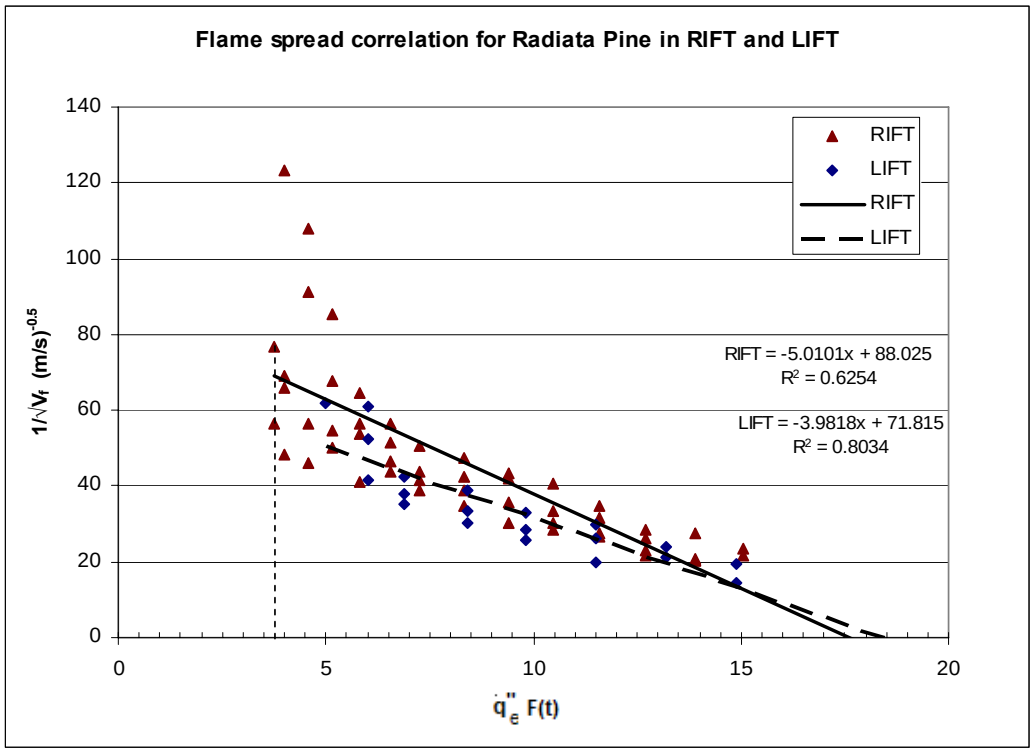



**Figure 130: Flame spread correlation for RIFT and LIFT**

## *9.4 Rimu*

### 9.4.1 Ignition of Rimu

The time to ignition for Rimu is shown in Figure 131. Rimu charred less than the softer woods such as Radiata Pine, but the samples tended to bow during the low heat flux tests, where the sample was exposed to long heating periods. It did not appear to have had a significant effect on the ignition results.

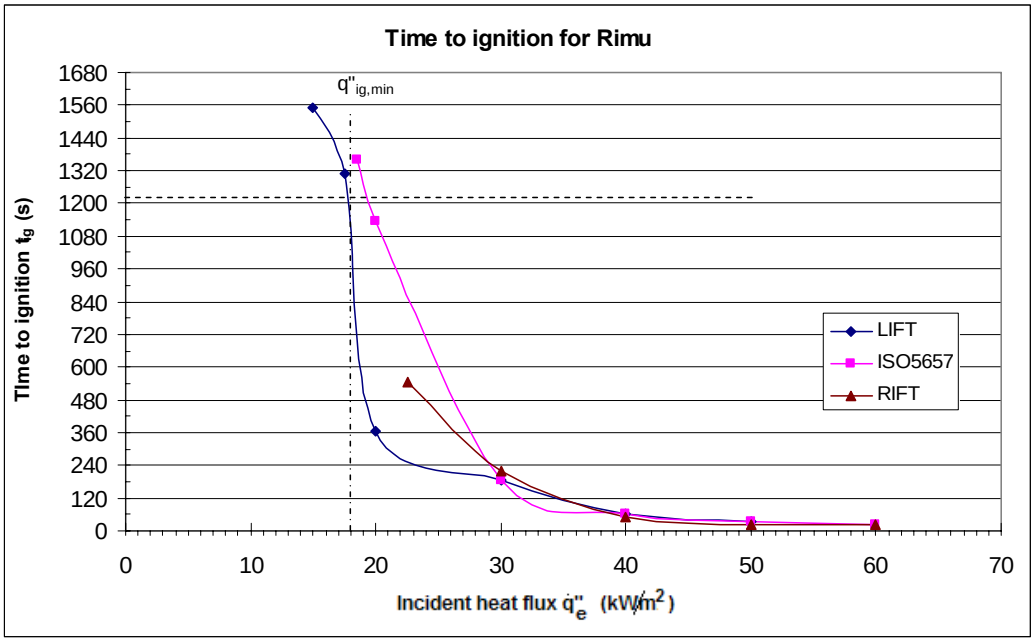



**Figure 131: Time to ignition of Rimu**

The resulting critical ignition flux (Figure 132) shows all the test methods gave similar results. The spread of the data was typical of the timber products tested.

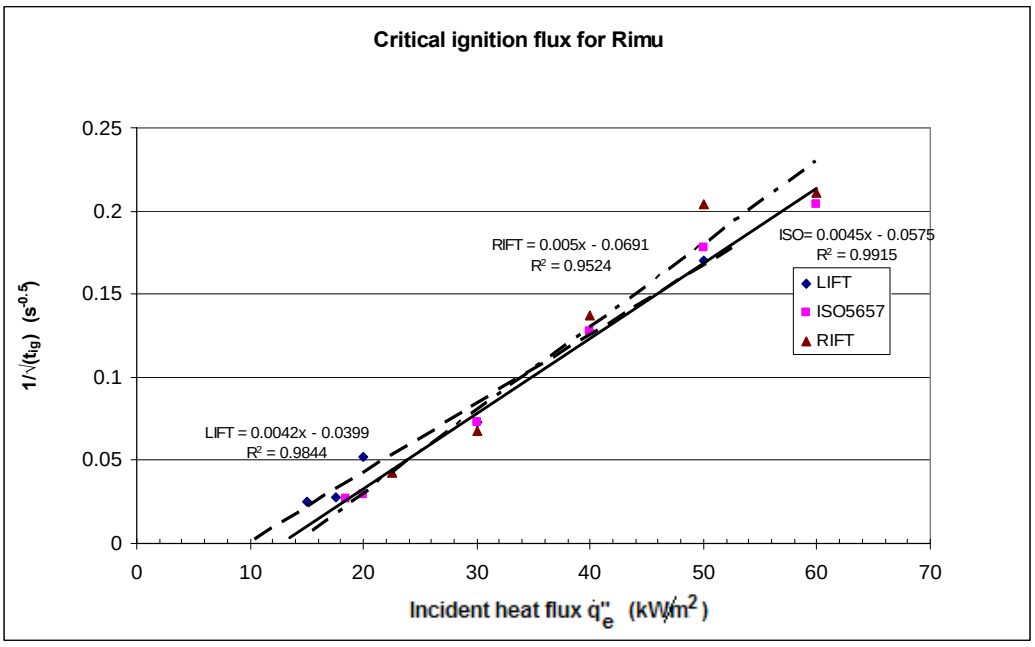



**Figure 132: Critical ignition flux for Rimu**

The fit of the ignition parameter for Rimu (Figure 133) required some data reduction. Most noticeably, the results for the RIFT ignition tests have significantly worse fit, given by the lower $R^2$ value, than those of the other methods.

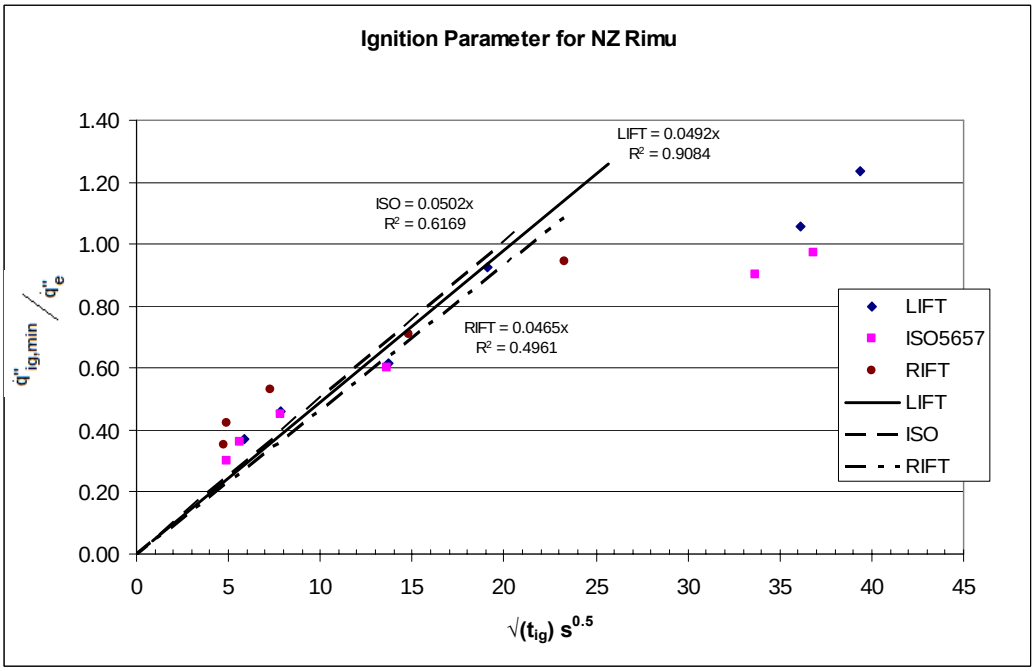



**Figure 133: Ignition parameter of Rimu**

### 9.4.2 Flame spread of Rimu

*Flame spread for Rimu in the RIFT*

There was insufficient flame spread in the RIFT with a full preheat period to get accurate data. The extent of flame spread was in the order of 130mm; however the initial 90-100mm was unusable, due to excessive charring. In this respect the extent of flame spread is similar to the case with a low preheat period (Figure 134). The low preheat period ranged from 67-80 seconds. The range was due to the time taken to get the sample to ignite after the preheating period. The full preheating period was 397 seconds, based on the ISO 5657 ignition data, or 395 seconds based on the LIFT ignition tests.

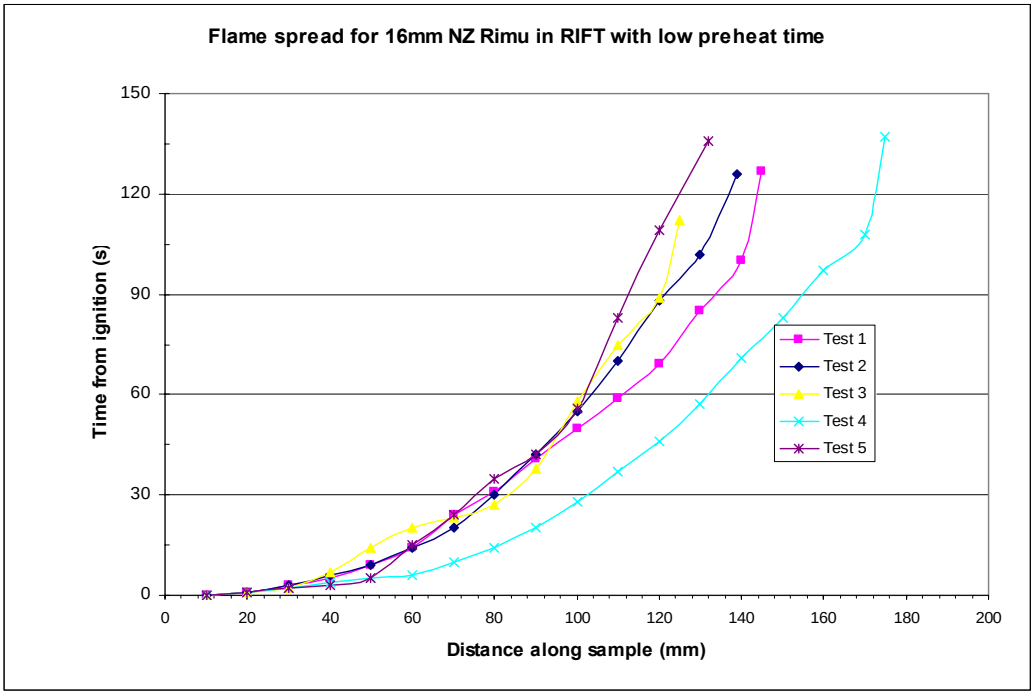



**Figure 134: Flame spread along NZ Rimu in RIFT with a low preheat time of 67-80 seconds**

*Flame spread for Rimu in the LIFT*

With the flux profile used in the flame spread tests in the LIFT, given in Figure 135, the resulting flame spread is given in Figure 136. The extent of flame spread in the LIFT results (Figure 136) shows significant variation, covering a range of over 125mm. Comparing this with the flux profile in Figure 135 gives a flux required for

flame spread ($\dot{q}''_s$) of between 5-10kW/m$^2$. This material would have benefited from more tests to give a more accurate estimate of the average value. The flux required for spread from the correlations (Figure 137 and Figure 138) is similar although generally lower than that based on the extent of flame spread. Both the RIFT and LIFT gave similar values for the correlated values for the minimum heat flux for flame spread, despite the lack of preheating in the tests with the RIFT.

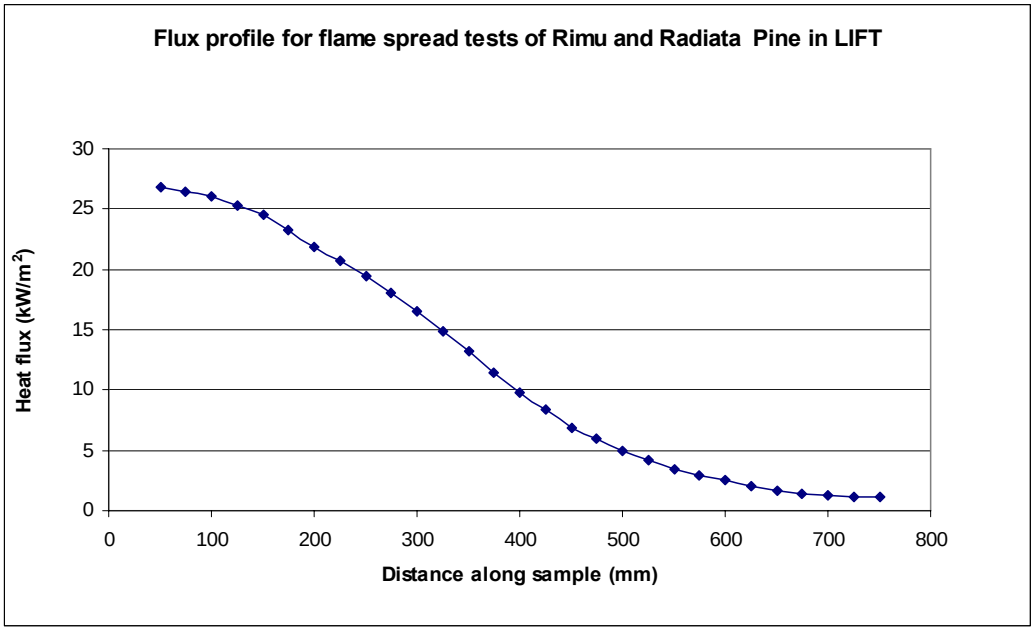



**Figure 135: Flux profile of LIFT flame spread test for Rimu and Radiata Pine**

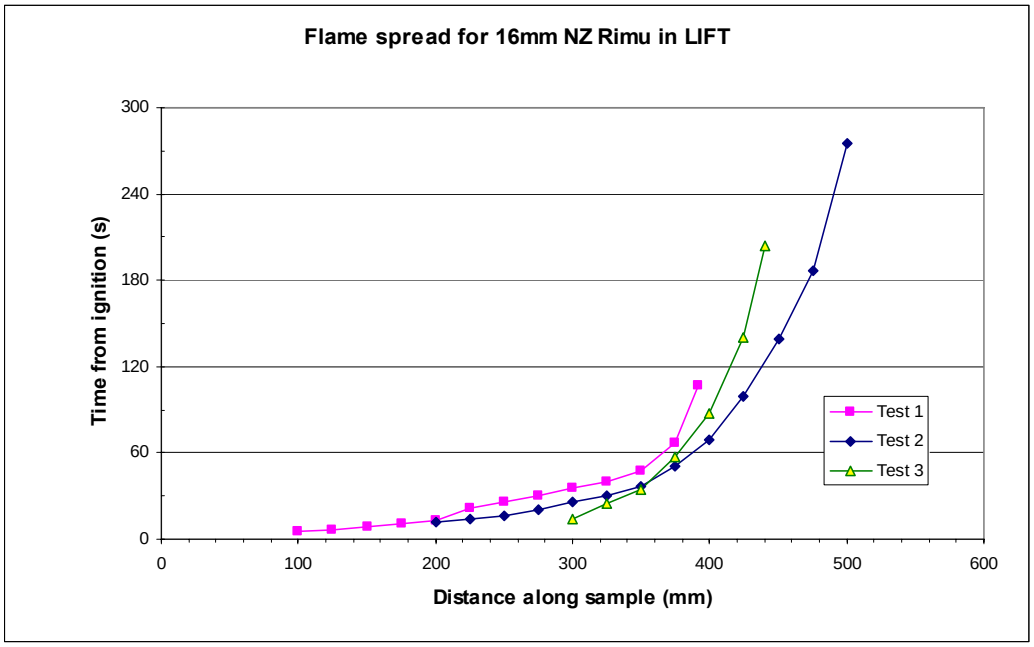



**Figure 136: Flame spread for Rimu in LIFT**

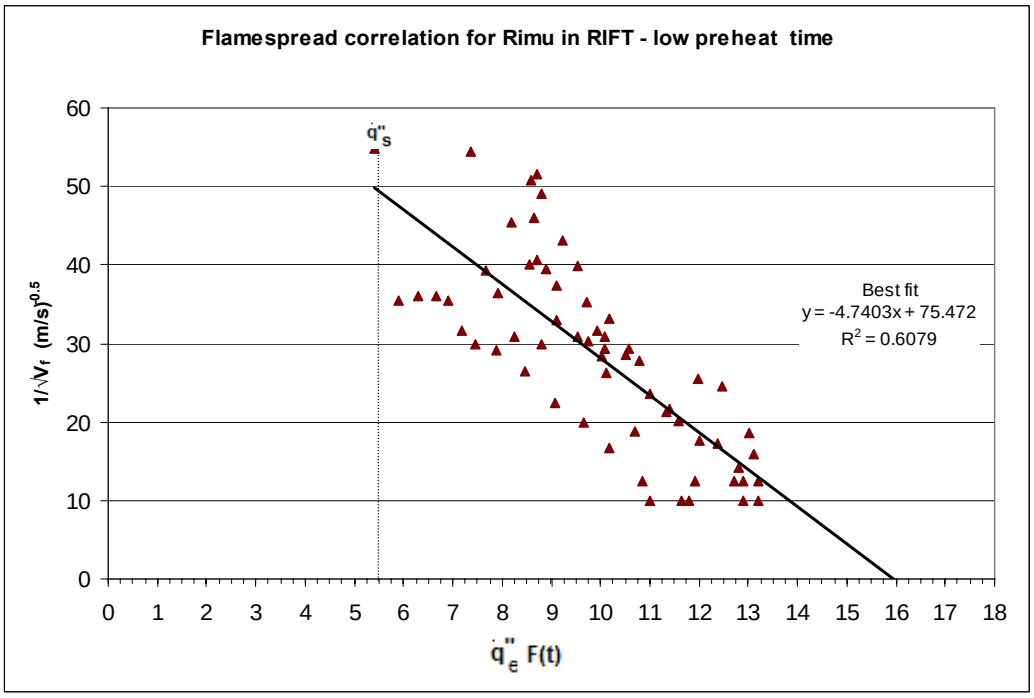



**Figure 137: Flame spread correlation for Rimu in RIFT with ISO 5657 ignition "*b*" value – 67-90 seconds preheat time**

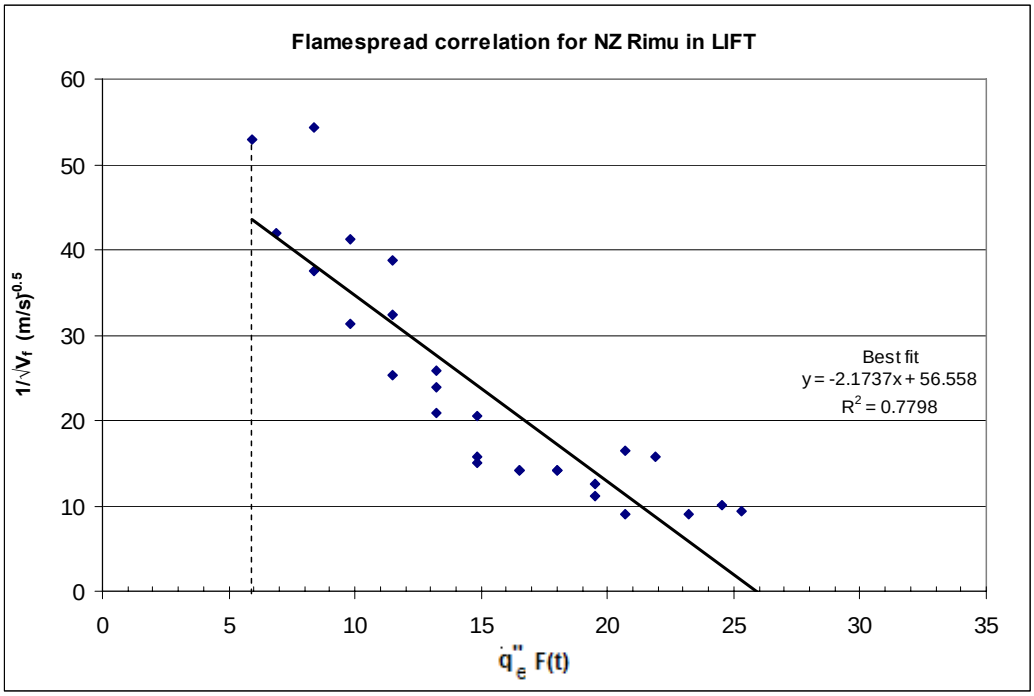



**Figure 138: Flame spread correlation for Rimu in LIFT**

# 10 Discussion of results

## *10.1 Equipment specific issues*

### 10.1.1 LIFT

The tests conducted for this report were the first results from the new LIFT testing machine at the University of Canterbury. In general, after initial teething problems, it performed well; however there are some improvements which can be made for future work

The limitation for the upper heat flux is dictated by the air supply. The air compressor which feeds the LIFT burner is also used for the air supply for other parts of the building. Using an 8cfm compressor in parallel with the main supply improved the consistency, and showed that over $\dot{q}''_{50mm}$ = 60kW/m$^2$ was possible; however the air supply was not consistent enough for extended running over 50kW/m$^2$. There are a number of alternatives. Another compressor could be mounted in parallel to provided additional capacity, or the burner can be redesigned to run on a lower pressure. The current burner design, seen in Figure 13, uses a 25mm square supply backbone with 6mm feeder tubes to the rear of the burner box, and semi circular baffles and Kaowool inside the burner box to distribute the gas evenly across the burner face. Replacing this with a larger tube would allow the air supply pressure to be reduced and a forward curve centrifugal fan could then be used for the air supply. If this is controlled with a variable frequency drive with RPM readout, then the air supply volume can be calibrated to the fan speed.

While the gas supply is controlled via a mass flow controller, the air supply is currently set with a variable pressure regulator and gauge, with a ball valve allowing additional restriction to be added to the regulator to stop fluctuation. The gauge is sufficient for crude adjustment, but the final mixture is set by the operator, based on the appearance of the flames from the panel and the required flux output. A highly precise adjustment has not proven to be necessary in practice, however easily repeatable settings would make the setup and changes to the flux levels faster and more consistent from run to run. This can be achieved with the current setup by using a 350-500 litre/min mass flow controller on the air supply, or changing to a variable speed fan with tachometer as described above.

Changing the burner system or modifying the manifold would also allow the burner to run at slightly lower flux levels than can currently be achieved. With flux levels less than $\dot{q}''_{50mm}$ = 25kW/m$^2$ the heating of the face of the burner becomes uneven, with a cooler section noticeable in the centre. An extra series of gas feed pipes into this area from the gas manifold backbone would help to reduce this problem.

The measurement of the heat flux is critical to accurate results. Due to the narrower angle of 15 degrees when compared with the RIFT, as well as the larger scale, with a shallower flux profile, this tends to be less critical than the RIFT. The positioning of the holes in the LIFT measuring template are specified with a 2mm tolerance. This is easily achievable when making the template, however it was noticed with use that the holes tended to wear and chip. The flux gauge was bent to allow it to be clamped to the rail behind the sample holder. A dedicated holder which would ensure that the face of the flux gauge was parallel with the face of the measuring template and not canted would give more consistent results. As the 50mm position is used the most, making extra templates with just this hole or reinforcing this hole to prevent wear is recommended.

While the calibration curve was within specification over the extent of the flame spread, it was outside the limit at the cold end of the sample. Some further adjustment of the apparatus may improve the match to the standard curve, however, this appears to be a common problem as it was reported by Nisted (1991) and Babrauskas and Wetterlund (1999). Pauner (2003) also reported the same issues with the IMO 653/ ASTM E 1317 round robin tests, which use the same equipment and calibration curve. At low flux levels, the errors in measurement become critical, and although the measurement results deviate from the standard value by a large percentage, the absolute value is low, and may approach the limits of accuracy of the measurements and the effect of variation from the burner. Robertson and Ohlemiller (1995) conducted tests to improve the consistency of measurements of the ASTM E 1317 marine finishes test at low flux levels. The error in measurements increased along the sample due to the effect of the convective boundary layer over the face of the sample. Their recommendation was that the face of the flux meter is proud of the surface of the measuring template to avoid the boundary layer. In practice, this is difficult as the refractory board is fragile and a thinner board will not last. The flux meter head

imposes a maximum thickness of the template board of 12mm in order for the face to be level with the template and not shielded inside the hole.

The observation of the flame front in the LIFT is either directly via marks on the sample or via the observation mirror and viewing rake. Measuring the flame front by observing the progress directly is easier and more accurate, as the flame front is ill defined at the initial stages, and can be difficult to see in the mirror, and errors are compounded by the effect of parallax and the width of the pins. . A problem shared by both the RIFT and the LIFT for directly observing the flame front is the charring of the material during preheating. Lines marked in pen disappear, but those done with a graphite pencil can often still be distinguished even though the surface of the material has blackened.

In order to increase the resolution and the number of data points collected, Dietenberger (1995) used a system where a pointer was moved via a hand crank parallel with the sample, in line with the flame front. The pointer was connected to a potentiometer and a data acquisition system, so that data collection is continuous and more automated with less chance of error. A modification for the University of Canterbury LIFT along these lines is recommended.

### 10.1.2 RIFT

Some of the comments noted for the LIFT also apply to the RIFT. The issue of the template holes wearing is more pronounced on the RIFT, as the combination of the smaller scale, the rapid decay of the flux profile and steeper angle between the element face and the sample makes the setup and calibration both more difficult and more critical. The rapid decay of the heat flux along the sample makes location of the measuring holes critical, as a small change in the position can make a large change in the actual heat flux. It is reasonably straightforward to get the location of the sample holder and the angle consistent between different experiment setups by measuring from the face of the cone calorimeter element, and the changeover time from the cone calorimeter in the horizontal position to the RIFT is usually between 15-20 minutes. Modifying the apparatus to use templates and locating stops would reduce this source of error further and make the changeover faster.

It is important when measuring the heat flux that the face of the heat flux gauge is parallel with the face of the template. This is easier than in the LIFT, as the operator can see the front face of the template. Due to the steeper 60° sample angle of the RIFT

against the 15° angle of the LIFT, small errors in holding the flux gauge in place can have a large effect. A mounting frame to provide consistency would reduce this error.

The accuracy of the data can be increased by increasing the number of reading points, preferably to every 10mm, which would coincide with the data collection points along the sample. This is not possible with a single template, due to the proximity of the holes. It can be achieved using 3 templates, with measuring holes at 30mm centres, and each template is offset by 10mm from the other templates.

Samples mounted in the LIFT are preset in a sample holder, which is slid into position. The RIFT as used in these experiments had a fixed frame, into which the sample and backing board was slid into place. This has the advantage of being easier to setup the sample, and makes tearing the foil backing less likely, and makes positioning the sample into place more consistent and faster.

The RIFT sample holder frame is mounted on an angle bracket, which allows the frame to pivot to change the sample angle, without changing the distance from the cone element. This forms a flange along the bottom of the sample holder, seen in Figure 38. This affects the airflow over the face of the sample, seen visually during the ignition tests from the behaviour of the smoke emitted from the sample. The ledge disrupts the airflow, reducing the cooling from the convective airflow – a flange is mounted on the bottom of the ASTM E 1621 ICAL intermediate scale calorimeter samples for the same reason (Babrauskas 2003). In the case of the RIFT, it decreases the time to ignition to close to that of the ISO 5657 ignition tests, where it would be expected to be higher due to the orientation. The minimum ignition flux is also increased. The effect of this is discussed in detail in the following sections; however it appears that the RIFT with the flange as currently constructed is not suitable for conducting the ignition tests which form part of the flame spread experiments.

The charring of the initial part of the sample in the flame spread tests obliterates the surface marks on the face of the sample. A series of pins as markers (Figure 139) was used to monitor the flame spread rate. Generally it was found that if the surface was too heavily charred, so that the pencil marks were no longer visible, then flame spread would be too rapid for accurate measurement, or the material would no longer ignite. In addition the error due to parallax and the width of the pins was too large given the scale of the sample and measuring positions to be generally worthwhile

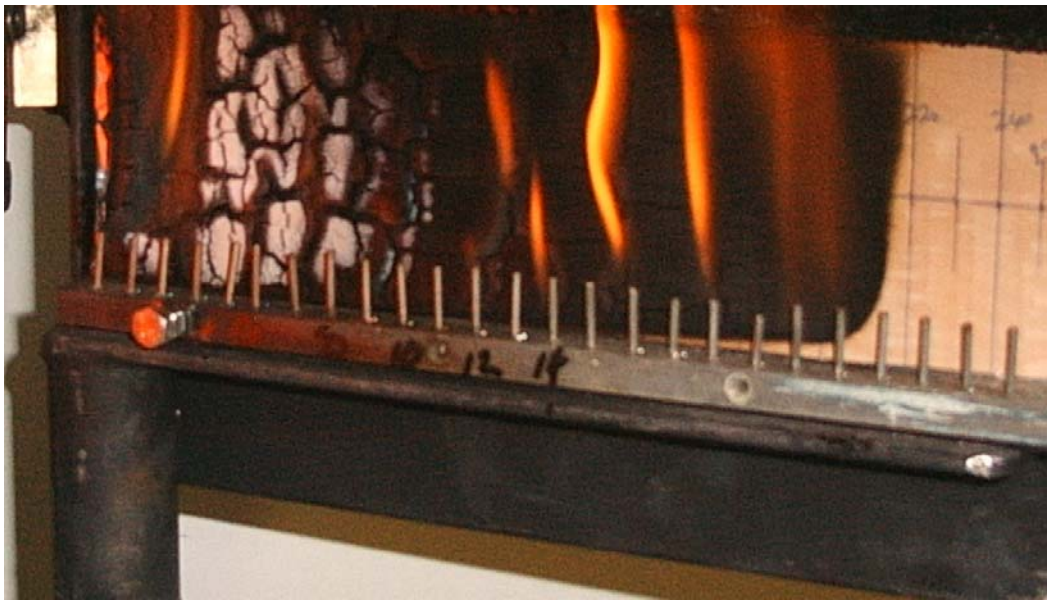


**Figure 139: Marker pins in RIFT**

## *10.2 Comparison of LIFT, ISO 5657 and RIFT ignition results*

The differences in the details between the apparatus, regarding sample size, orientation, pilot and heating source, etc are expected to affect the ignition results, and hence the values subsequently calculated.

The RIFT has a ledge at the front as part of the mounting frame and this affects the convective flow across the face of the sample. The ASTM E 1623 ICAL intermediate scale calorimeter uses such a ledge to prevent convective cooling of the exposed sample surface, as the ignition time results are otherwise far greater than those produced by other methods (Babrauskas, 2003).As the radiatve component of the heat transfer coefficient is expected to be unaffected by the ledge, it appears that the RIFT as used in these experiments appears to have a lower convective coefficient $h_c$ than the LIFT. This gives a correspondingly reduced heat loss from the face of the sample, and consequently the RIFT has shorter ignition times than the LIFT. The ASTM E 1321-97a standard specifies that the LIFT has a heat transfer coefficient of 0.015kW/m$^2$K, including the convective component, although Dietenberger (1996) found the heat transfer coefficient was much higher at the hot end of the sample. This

was due to the effect of turbulence induced by the gas burner, and was a function of the heat flux at the point, and the convection coefficient varied along the sample.

The heat transfer coefficient for the cone calorimeter is approximately 0.010 $kW/m^2K$ (Janssens et al, 2003), and Babrauskas and Wetterlund (1999) used a value from other research of $0.0115kW/m^2K$. Babrauskas (2003) gives the convection coefficient for the cone calorimeter in the vertical position as 20% higher than in the horizontal position, or $0.012kW/m^2K$. Dietenberger (1995b) found that it was a function of the received heat flux, in the same manner as the LIFT. The RIFT would therefore be expected to have longer ignition times than the ISO 5657 apparatus, due to the orientation, in the same manner as the LIFT. Since the ignition times for the RIFT were similar to the ISO ignition test results, as discussed in more detail below in section 10.2.2, then this implies that the convection coefficient for the RIFT is similar to the ISO ignitability apparatus.

The effect of the larger sample size in the LIFT is expected to be less of a cause for the difference in results. The main difference in the heat loss from the surface between a LIFT and RIFT sample is convective, and the convective coefficient $h_c \propto$ (sample height)$^{1/4}$ (Babrauskas, 2003).

### 10.2.1 The effect of data reduction of ignition data

As noted in section 3.4.2, the data reduction undertaken can greatly affect the results of the test, by affecting the preheating time $t^*$ and the ignition parameter *b*, from the slope of the fitted data points. As given in Equation (32), the thermal equilibrium time $t^*$ equals [1/(ignition parameter *b* )]$^2$, a small change in the fit of the data points leads to excessively long or short preheating times. The effect of insufficient preheating is a curvature in the flame spread correlation, and a poorer linear data fit. The points which are discarded as being a poor fit are generally obvious, and the process given in section 3.4.2 appears to give consistent results.

This is an area recognised by others (Babrauskas and Wetterlund, 1999) as an area which is unclear within the standard, and a definite procedure should be included in future revisions for consistency and clarity.

### 10.2.2 Time to ignition

The time to ignition between the ISO 5657 apparatus and the LIFT (Figure 140) follows the expected behaviour shown by Dietenberger (1995), where the ignition

times are longer in the LIFT than the ISO 5657 test, although not as marked, as the average difference is 4.3% in these tests. While the difference is greater at lower flux levels, the scatter of the results is also greater, and this tends to hide the trend at flux levels less than 30kW/m$^2$. This is also noted by Babrauskas (2003).

Shields, Silcock and Murray (1993) investigated the time to ignition for particle board, plywood and spruce softwood in the horizontal and vertical positions in the ISO 5657 ignition apparatus and in the cone calorimeter, as well as inverted in the ISO 5657 apparatus. The cone calorimeter and the ISO 5657 apparatus produced similar ignition results. In all cases, where the sample was in the vertical orientation, the ignition times were significantly increased for flux levels between 20 and 40 kW/m$^2$.

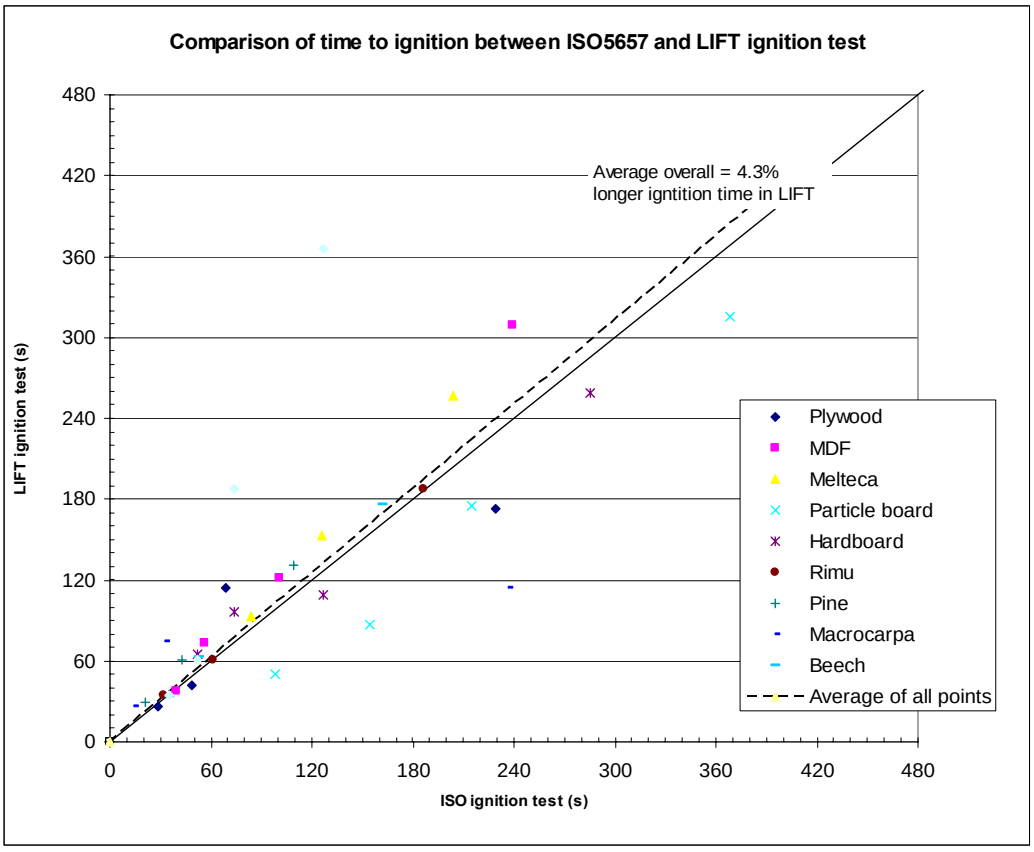



**Figure 140: Comparison of time to ignition for ISO 5657 and LIFT ignition test**

The trend is similar with the RIFT vs. the LIFT, with the LIFT having higher times to ignition than the RIFT (Figure 141). The time to ignition for the RIFT and ISO 5657 are similar (Figure 142)

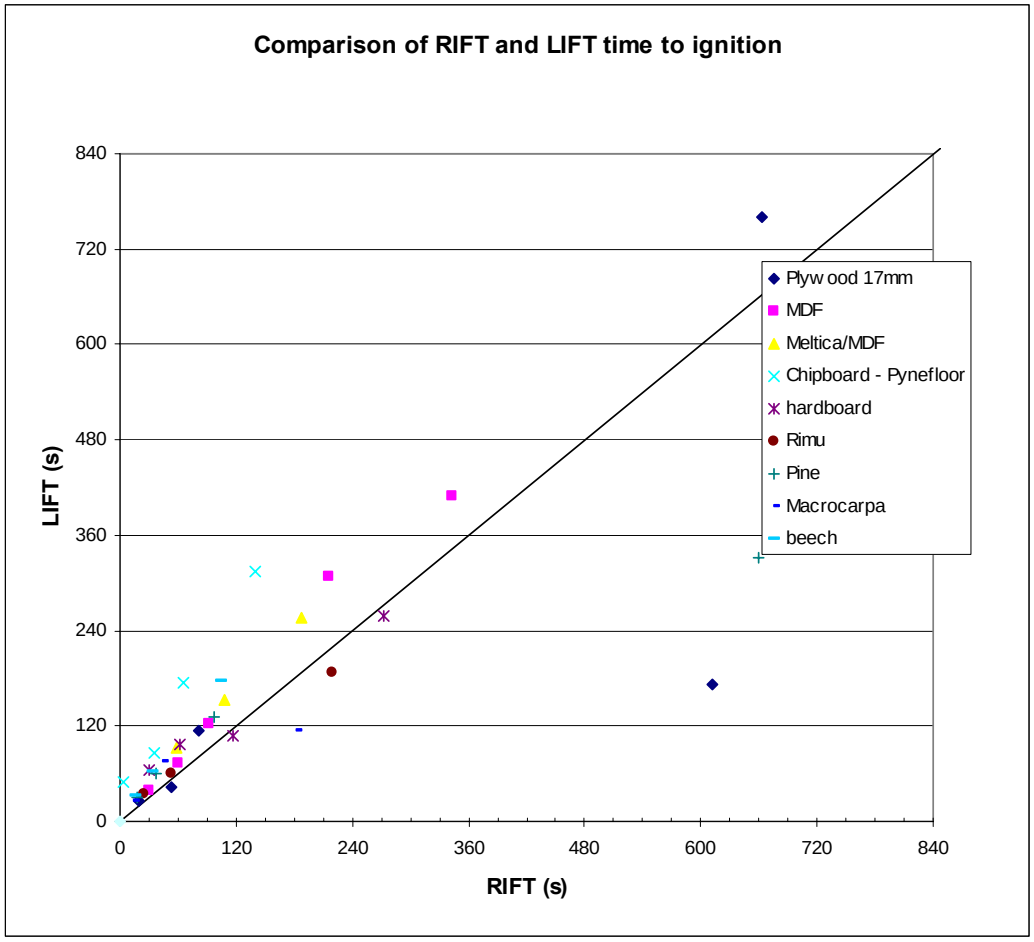



**Figure 141: Comparison of time to ignition for tests in RIFT and LIFT**

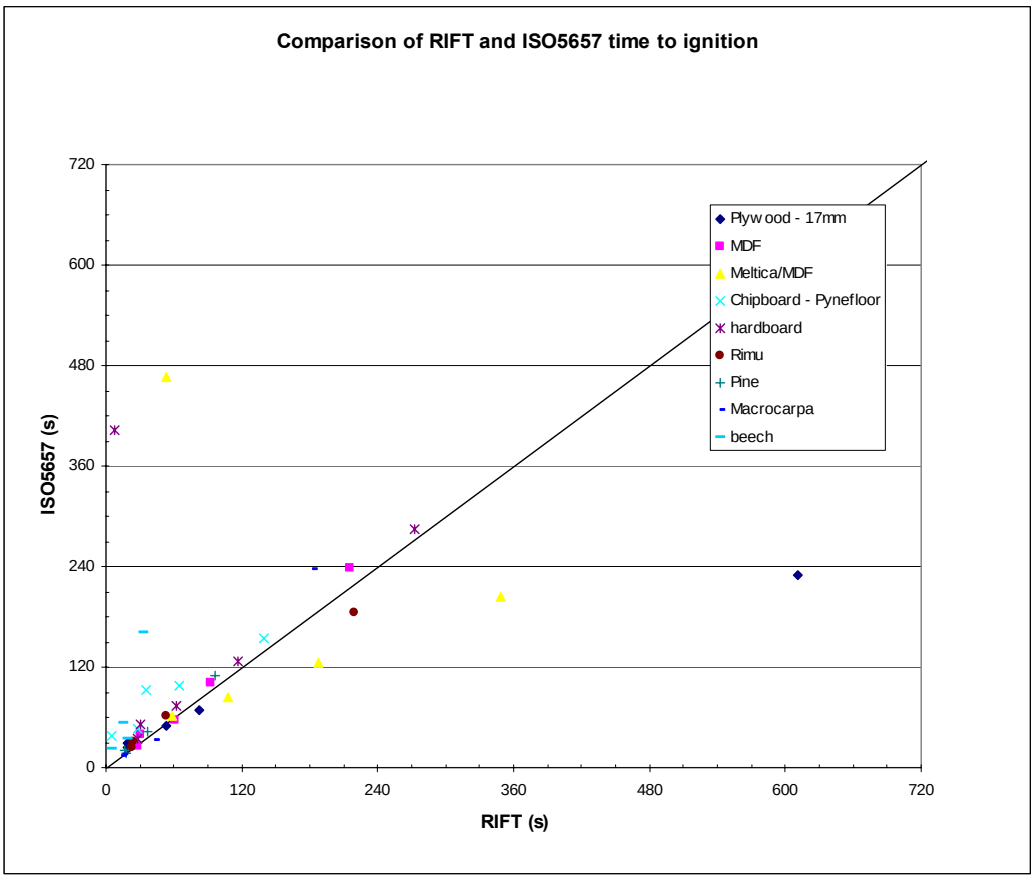



**Figure 142: Comparison of time to ignition for tests in RIFT and ISO 5657 ignition apparatus**

### 10.2.3 Thermal inertia kρc

The thermal inertia is compared in Figure 143, where the differences between the types of apparatus are apparent. The ISO 5657 apparatus produces higher thermal inertial values than the LIFT. The RIFT shows much more variation and spread compared with the other methods, giving more inconsistent results when it is applied to calculate the flame spread parameter.

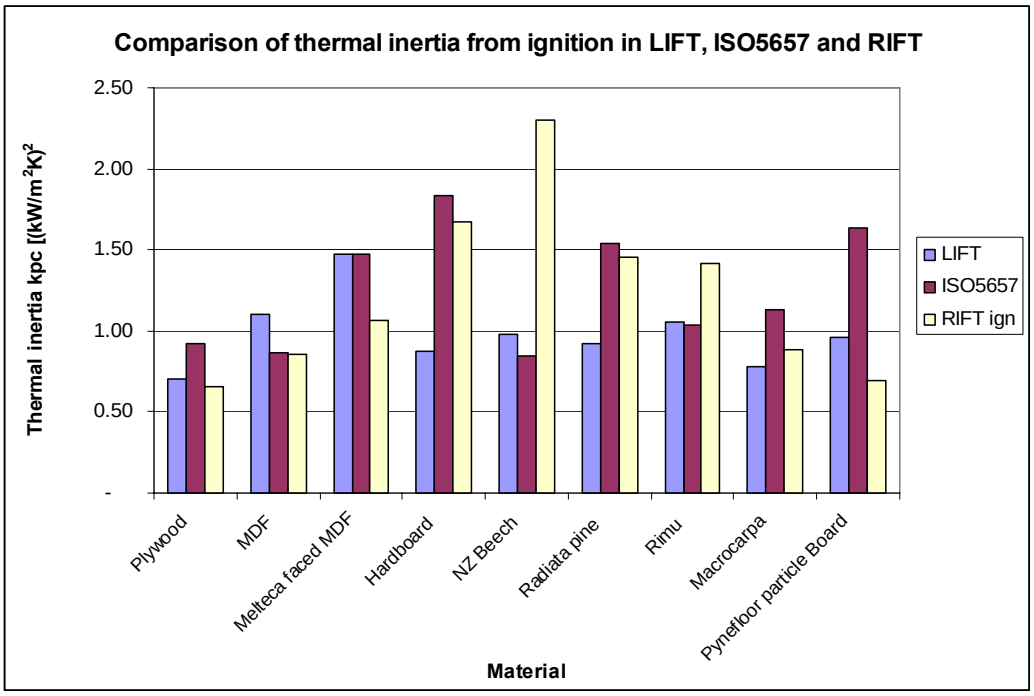



**Figure 143: Comparison of thermal inertia ($k\rho c$) in LIFT, ISO 5657 and RIFT**

### 10.2.4 Minimum ignition flux

The minimum ignition flux is compared in Figure 144, where the ISO 5657 ignition test gives a consistently lower value for $\dot{q}''_{ig,\min}$ than the LIFT. The RIFT is generally greater than or equal to the LIFT values.

As a comparison, Dietenberger (1996) found that the minimum ignition flux for redwood was 4kW/m$^2$ greater in the LIFT when compared to the cone calorimeter in the horizontal position. Given that the ISO 5657 and cone calorimeter tests give similar results for the minimum ignition flux (Babrauskas, 2003), then the values from

ignition tests in the LIFT would be expected be higher than those obtained in the ISO 5657 ignition tests. This can be seen in Figure 144.

The higher minimum ignition flux for the RIFT ignition, combined with the lower ignition times gives a higher ignition parameter value "b", which affects the final flame spread parameter $\Phi$ value.

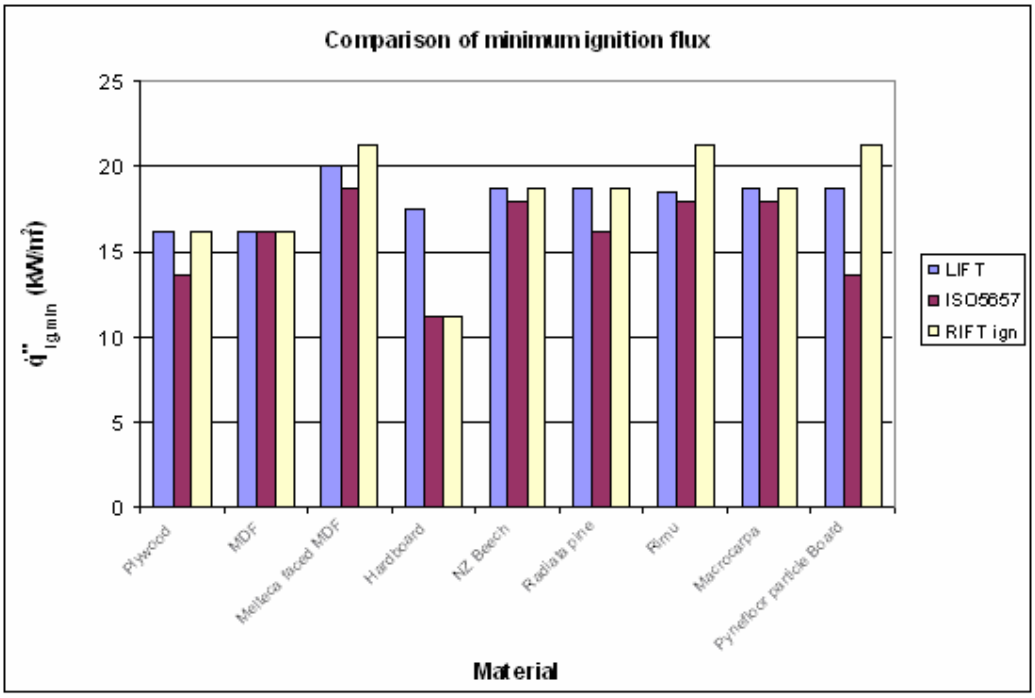



**Figure 144: Comparison of minimum ignition flux $\dot{q}''_{ig,\min}$**

### 10.2.5 Comparison of correlation values and measured minimum ignition flux $\dot{q}''_{ig,\min}$

The comparison of the correlated value and the measured value for the minimum ignition flux ($\dot{q}''_{ig,\min}$) is shown below for both the RIFT (Figure 145) and the LIFT (Figure 146). The values of the minimum ignition flux from the flame spread correlation, given in the procedure in Section 3.4.4, are consistently higher than the

experimental values. Babrauskas and Wetterlund (1999) also noted this finding with their results, where they used the LIFT for both the ignition tests and flame spread.

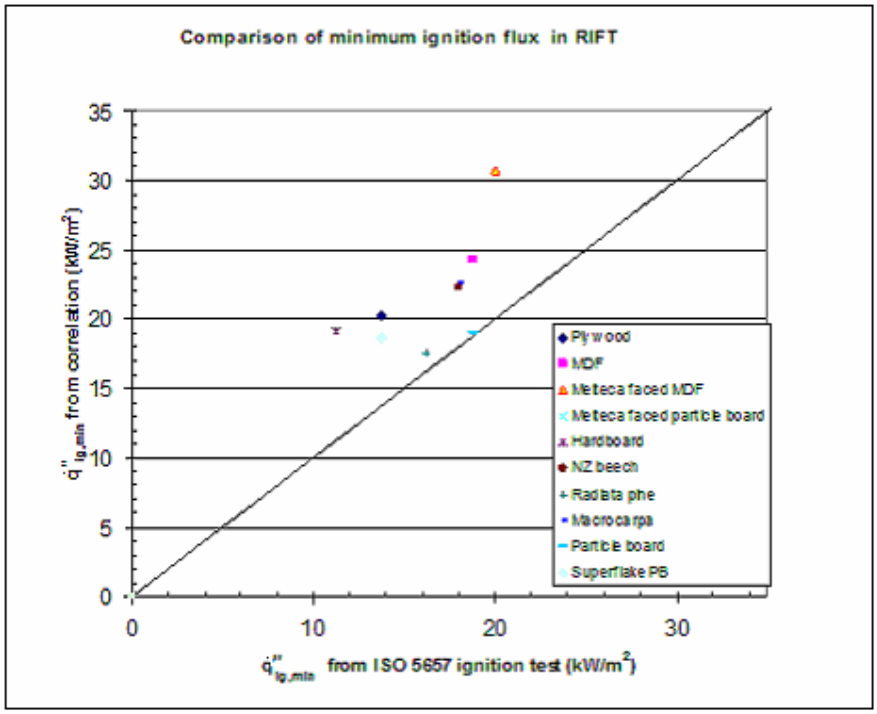



**Figure 145: Comparison of RIFT flame spread correlation and ISO 5657 ignition test results for minimum ignition flux $\dot{q}''_{ig,\min}$**

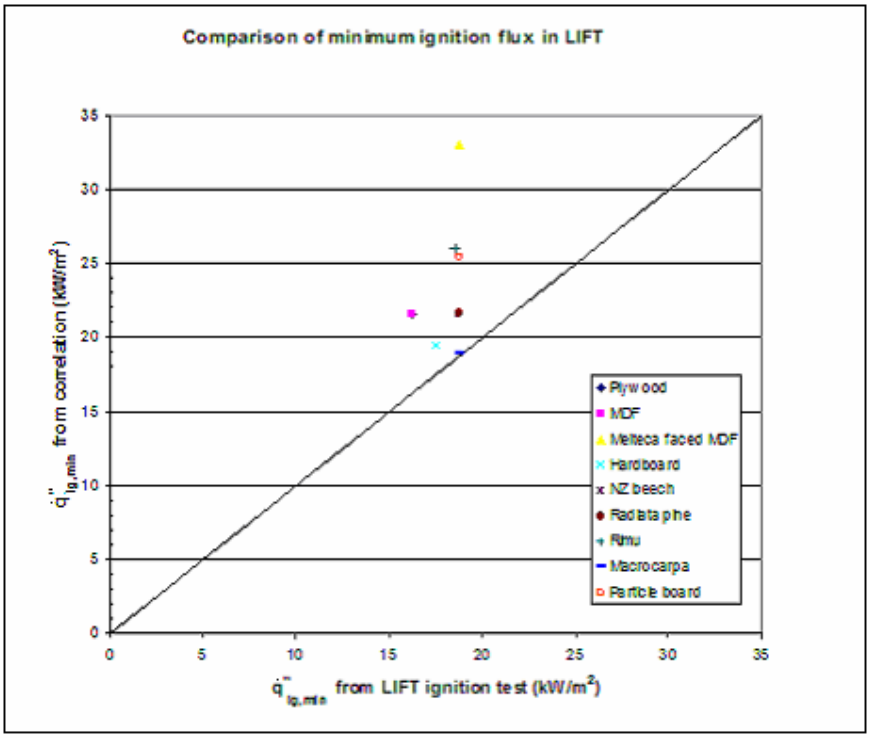



**Figure 146: Comparison of LIFT correlation and LIFT ignition test results for minimum ignition flux**

### 10.2.6 Apparatus and flame spread

It is apparent when looking at the flux distribution in the RIFT in Section 6.2, reproduced below in Figure 147, that the apparatus is limited to materials with a relatively low value for the minimum flux required for flame spread ($\dot{q}''_s$), in order to get sufficient flame spread along the sample.

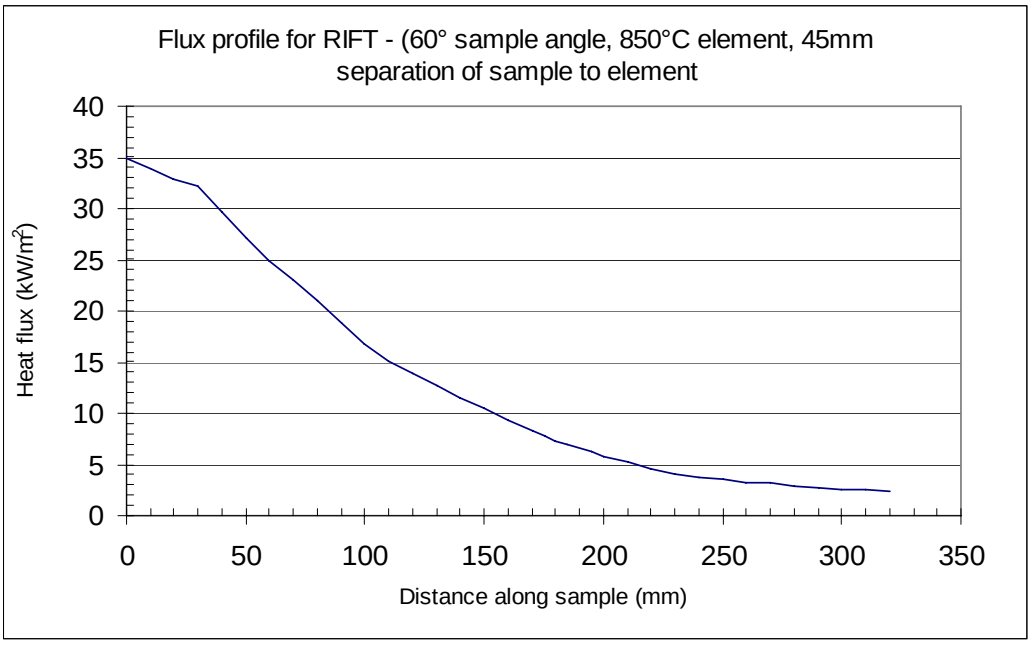



**Figure 147: RIFT irradiance curve**

As the initial 80mm of most timber based samples in the RIFT was unusable for the flame spread test due to excessive charring during the preheat period, the practical limit in order to get sufficient data is around $\dot{q}''_s$ = 7kW/m$^2$, giving flame spread measurements along to 180mm from the hot end of the sample. The rapid decay of the flux profile around this point makes the measurement of the flame spread velocity more difficult, as there is a significant change between each measuring point. Samples with a lower flame spread parameter $\Phi$, which consequently have a lower flame spread velocity, will give more accurate results.

It is important that the markings on the sample match their position. A small variation of the actual position against the expected position (with the measured heat flux) will introduce errors in the RIFT measurements, due to the more rapid decay of the flux profile and the smaller resolution. As the LIFT has a shallower flux profile and a

longer sample area, it is not as critical in this regard. A tolerance of ±2mm is listed for the LIFT. The LIFT uses a sample holder which is slid into place against a stop, allowing it to maintain the positioning, whereas the RIFT as currently designed has the sample slide directly into a sample holder frame, giving less consistent positioning, due to the effect of the aluminium foil backing bunching at the ends of the sample. The separate frame allows this to be taken into account when the sample is setup in the sample, so it can be zeroed accurately prior to insertion.

### 10.2.7 Comparison of ignition parameter "b"

The ignition parameter "*b*", calculated from the ignition data, depends on the minimum ignition flux $\dot{q}''_{ig,\min}$, which has been shown to be dependent on the ignition apparatus, as well as the data reduction, as excluding data points can make a significant difference to the final value. As a result, the value of the ignition parameter can be expected to vary between the ignition methods used. Figure 148 shows that the data from the LIFT tests tends to give slightly higher ignition parameter values for the materials tested. This is expected to be largely due to the higher $\dot{q}''_{ig,\min}$ values that this ignition test gives compared with the ISO 5657 test.

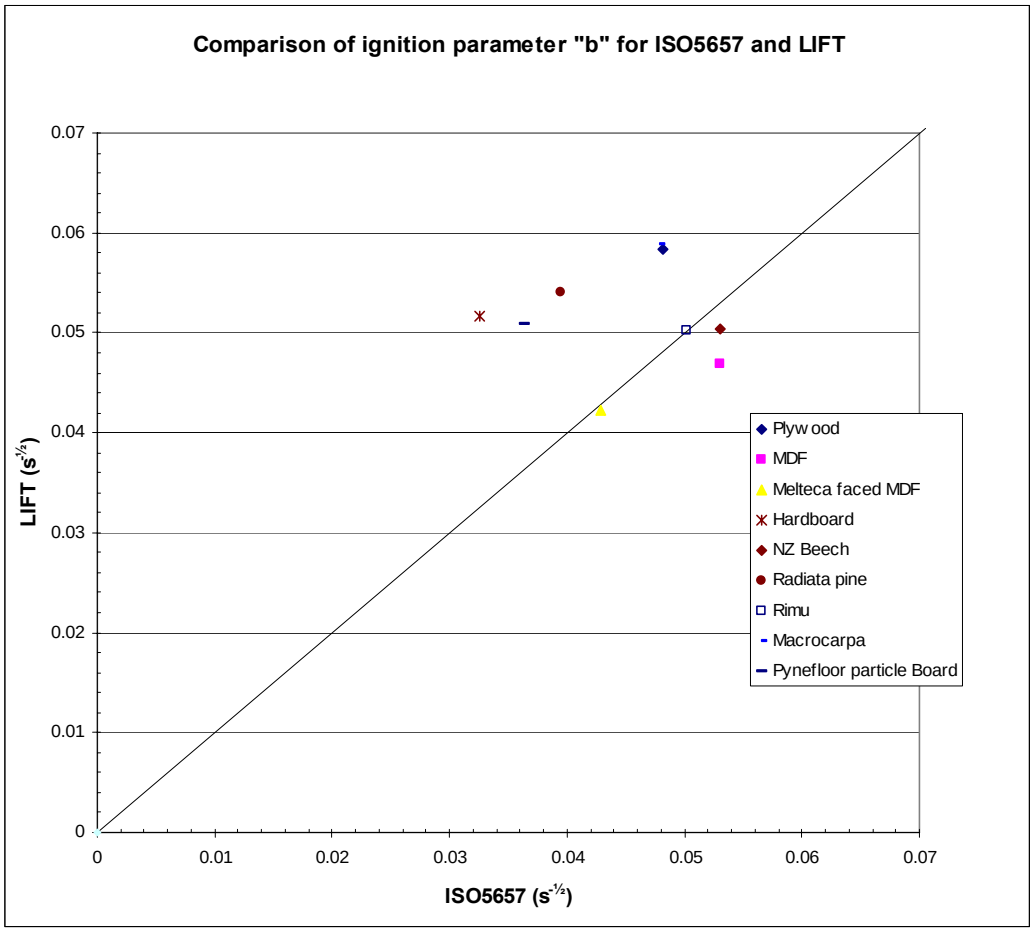



**Figure 148: Comparison of ignition parameter "*b*" in ISO 5657 and LIFT**

### 10.2.8 Flame spread parameter $\Phi$

From equation (34), reproduced below in equation (46), the flame spread parameter depends on the ignition parameter "*b*" value. As noted previously, this can vary depending on the data reduction used, and the experimental apparatus. The effect this has can be seen by a 10% change in the ignition parameter value in the range of the materials tested, which leads to approximately a 17% reduction in the resulting flame spread parameter.

$$\phi = \frac{\frac{4}{\pi}}{(Cb)^2} \qquad \textbf{(46)}$$

Generally the flame spread parameters calculated from the RIFT tests are higher than those from the same material in the LIFT (Figure 149). The results based on the ISO 5657 ignition data show less scatter than those on the RIFT ignition tests, reflecting the variation in the ignition results using the RIFT for ignition testing.

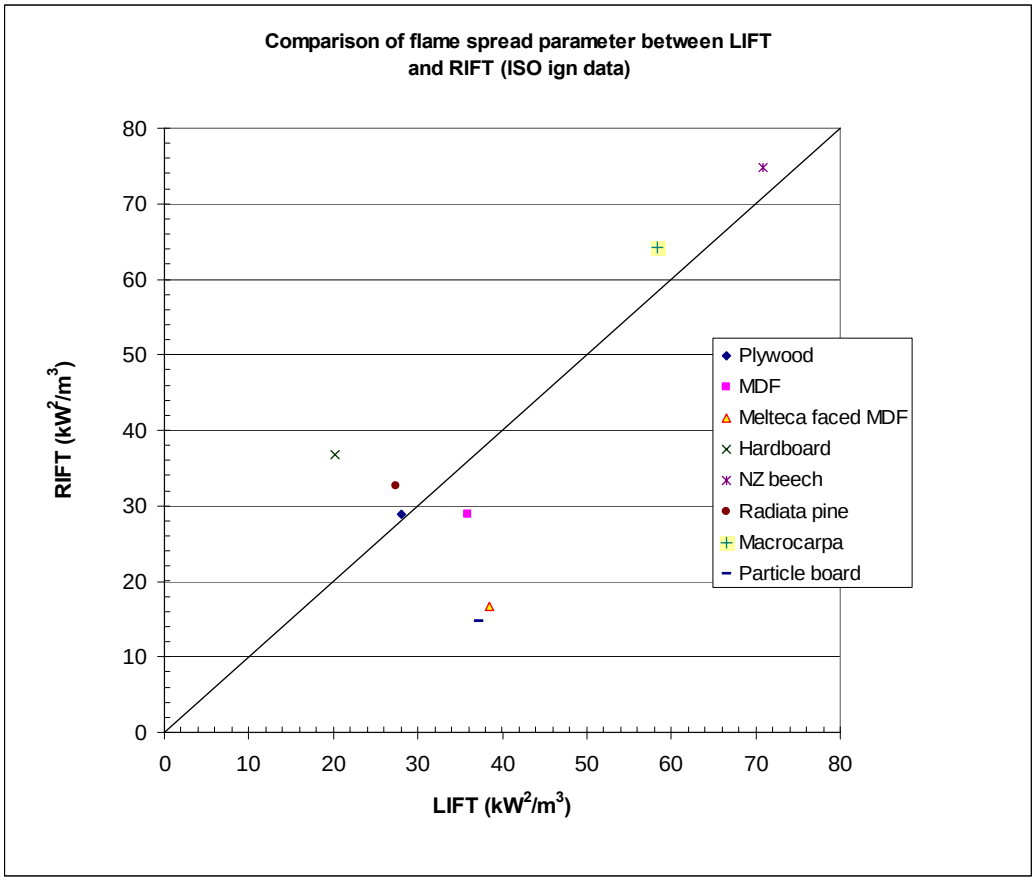



**Figure 149: Comparison between flame spread parameter for LIFT and RIFT (using ISO 5657 ign data for RIFT)**

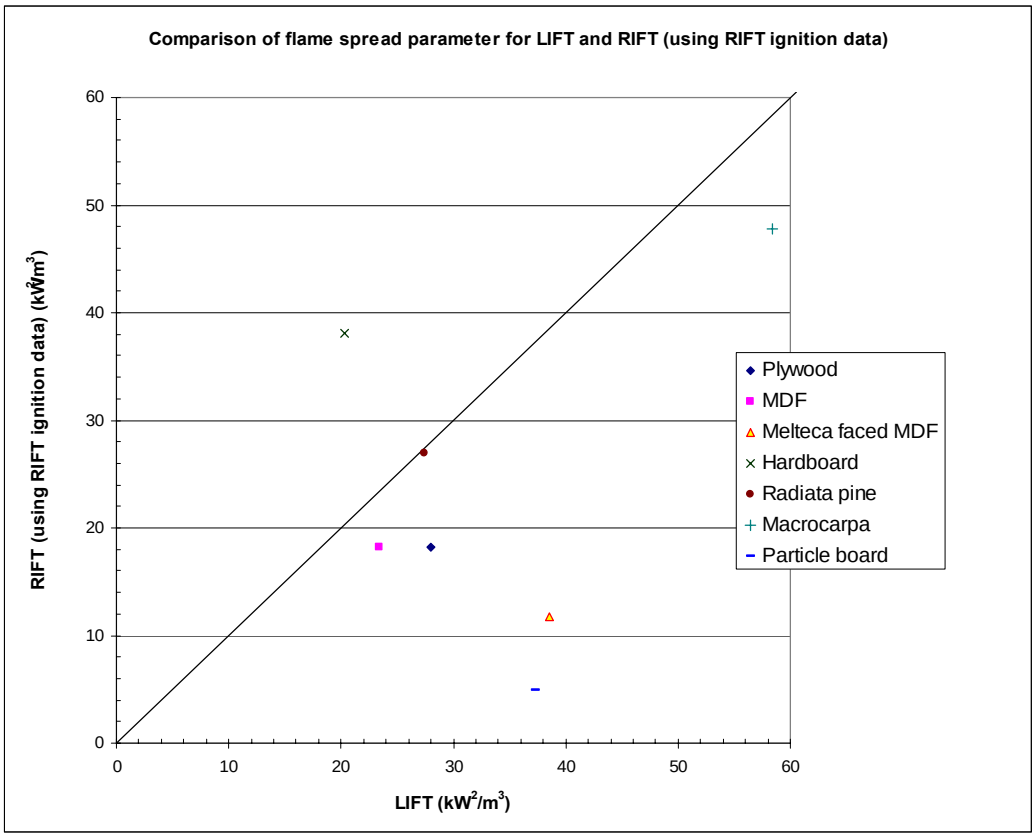



**Figure 150: Comparison of flame spread parameter for LIFT and RIFT (using RIFT ignition data)**

### 10.2.9 Minimum heat flux for flame spread

A limiting factor to the RIFT test is the minimum flux required for flame spread ($\dot{q}''_s$), as if this value is too high, then there is insufficient flame spread distance to give accurate results. The results are generally comparable for the LIFT and RIFT (Figure 151). The outliers of Rimu and Melteca faced MDF are largely because the flame spread stops in the area where the profile is rapidly diminishing with a change of 4kW/m$^2$ over the 25mm measuring interval of the flux measuring template, so a small error in the location can have a large effect on the final outcome.

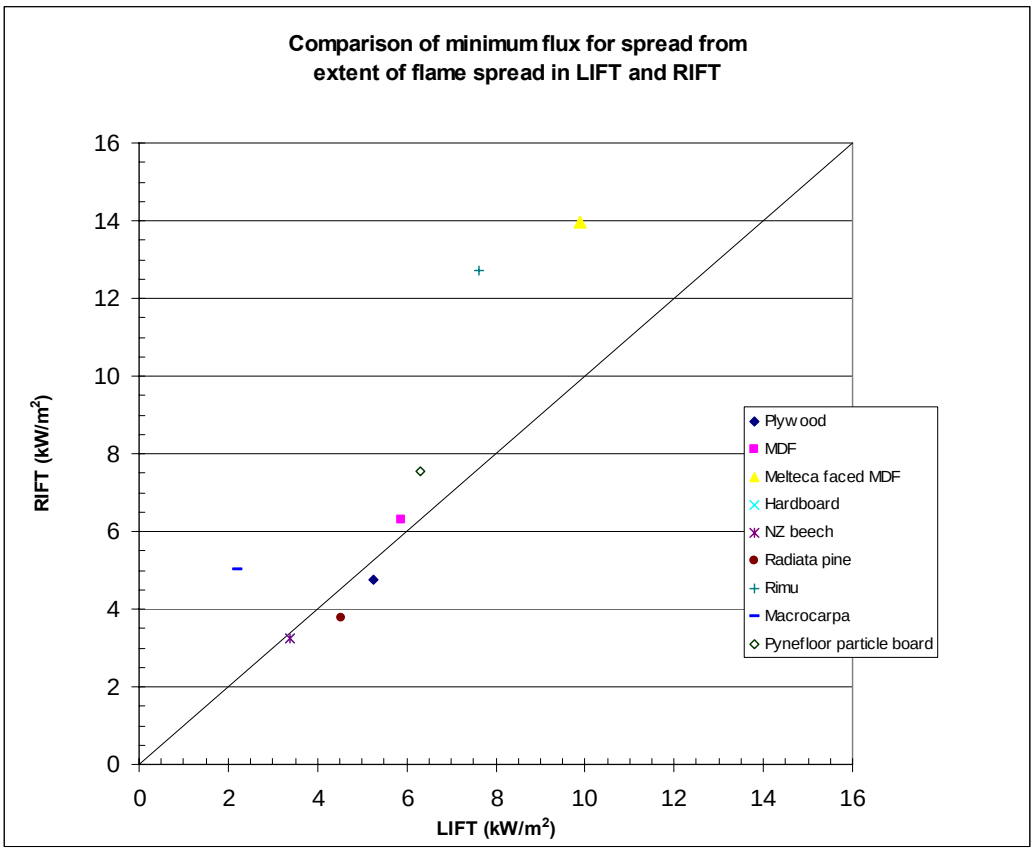



**Figure 151: Comparison of minimum flux for flame spread $q_s''$ in LIFT and RIFT**

The results where there is a closer match are for materials where $\dot{q}_s''$ < 7kW/m$^2$, giving a practical limit to the RIFT test for materials to get comparable results. This limit does depend on the flame spread behaviour of the material, and the effect of charring due to the preheating. If the flame spread rate is sufficiently low, and data can be obtained over the area that is normally too heavily charred to ignite easily, then it may be possible to get useable data above this level. The value for the experimental minimum heat flux for flame spread $\dot{q}_s''$ is still going to have significant error due to the rapid change in the flux profile in the RIFT in this area.

Given that the minimum flux for spread is not known until the material is tested, an estimate of the likelihood of success of the RIFT flame spread test is necessary from the ignition tests. A comparison of the minimum ignition flux and the flux required for spread shows a poor correlation (Figure 152), however the products for which no flame spread results were possible (the Melteca faced boards, and Rimu) all have highest minimum ignition flux. This indicates there is an approximate limit for the

minimum ignition flux of $\dot{q}''_{ig,\min} < 18$ - 19kW/m$^2$ for a successful flame spread test in the RIFT.

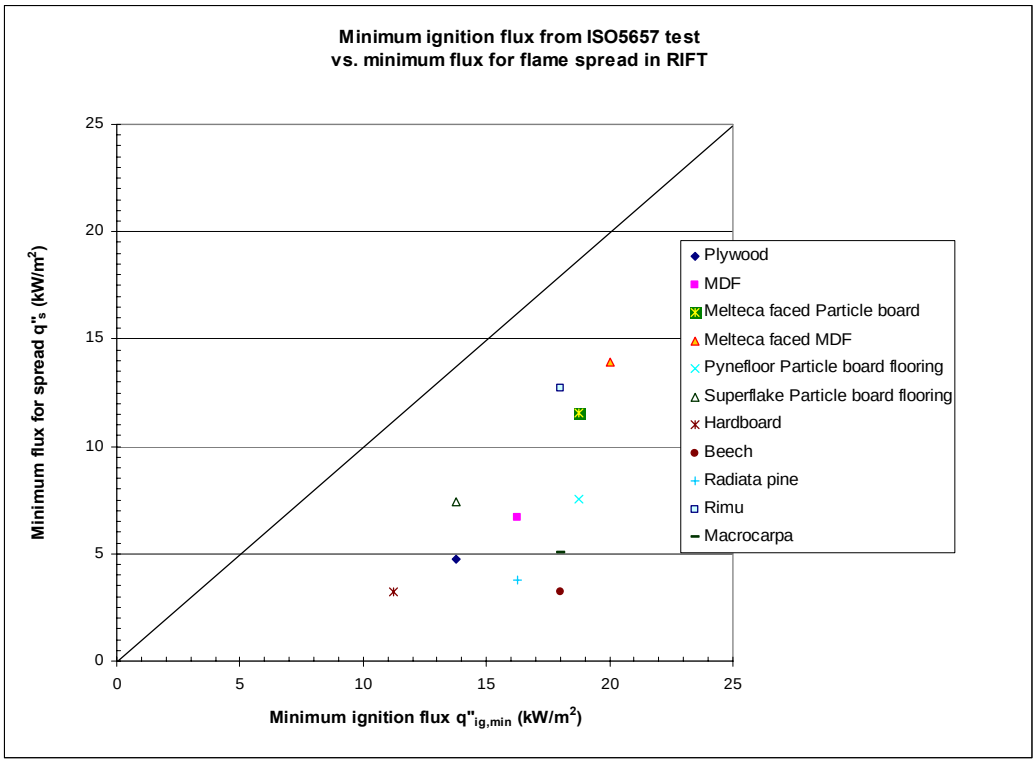



**Figure 152: Minimum ignition flux from ISO 5657 test vs. minimum flux for spread for RIFT**

## *10.3 Material and operational differences*

### 10.3.1 Effect of preheating

Quintiere (1981, 1983, 1984), and the resulting ASTM LIFT standard calls for the material to be preheated so that the surface reaches equilibrium, and hence the time transient function *F(t)* =1, simplifying the data reduction. It is also justified for fire modelling as the walls are expected to be heated by the fire in the compartment and it gives a more conservative approach as the calculated flame spread velocity will be higher. The process of preheating the material changes the material properties, such as drying the moisture from the wood, and charring or melting the material. These changes are not constant along the sample – the charring of the sample occurs at the hot end of the sample, where as the cold end is close to room temperature. With excessive preheating times the material can char to such an extent that the material

can no longer be ignited. This problem occurred with hardboard in the RIFT, which had a longer preheating time than in the LIFT due to the results of the ISO ignition test. The material charred to such an extent that it cracked and fell out or self ignited, so the shorter LIFT preheating time was used. This issue also occurred for the tests conducted by Nisted (1991) where some materials would not ignite when tested with the standard preheating period, so only half the preheat period was used on those materials.

Babrauskas (1999) reports that some of the materials tested, which covered a wider range of material types than these tests, gave more consistent results when no preheating period was used. The results from these tests indicate the opposite for these materials, with the flame spread rate and the correlations showing far more variation than when the material is preheated fully, for example, the results for particle board given in Figure 62 - Figure 65.

The issue of charring of the material during the preheating period makes the first 80mm in the RIFT, and 150-200mm in the LIFT effectively useless for flame spread measurements. The material is above the minimum ignition flux, so that the flame spread travels across the material in this region almost instantly.

The effect of preheating on the flame spread correlation and the slope of the data points, from which the flame spread parameter is calculated, is shown in Figure 153. The slope, which equates to the flame spread modulus $C$, decreases as the material is preheated until equilibrium is reached (i.e. $F(t)=1$), due to the scaling effect of the $F(t)$ time transient function.

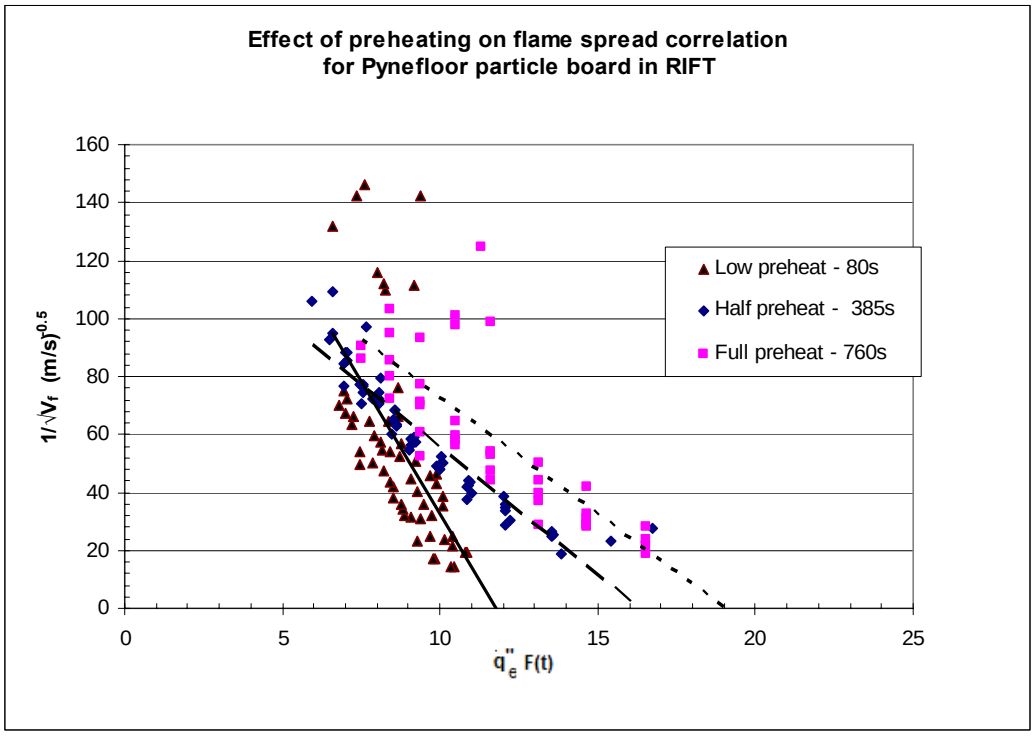



**Figure 153: Effect of preheating on the flame spread correlation for Pynefloor in RIFT**

The preheat times for Figure 153 were approximately 80 seconds, 385 and 760 seconds, where 755 seconds was the calculated time for the surface to reach equilibrium from the ISO 5657 ignition tests.

### 10.3.2 Effect of substrates on Melteca and facings on boards

It is apparent from the tests on the Melteca faced boards, outlined in Section 8.4.3 that having a layer with a higher minimum ignition flux over the comparatively more flammable substrate gives inconsistent results in the LIFT tests (, and these results are worse in the RIFT (Figure 97 and Figure 98) due to the smaller scale and more rapid decay of the flux profile.

### 10.3.3 Effect of thickness

There is a limitation on the theory given in the ASTM E 1321 LIFT standard that the material is assumed to be thermally thick. As an illustration of the effect of the sample thickness on the ignition time, 9mm and 17mm plywood with a 12mm lightweight Kaoboard insulated backing board were compared with ignition in the RIFT (Figure 154). At high heat fluxes, the time to ignition is the approximately the same, regardless of the thickness, as the thermal penetration depth is less than the sample

thickness. As the time to ignition increases, the thermal penetration is greater than the thickness of the thin sample, and as the backing board is a good insulator, there is little heat loss from the back of the sample into the backing board, hence the sample tends to become thermally thin, the sample temperature increases and the ignition time is less. With the thicker sample, there is still heat loss into the unheated part of the sample, leading to a longer ignition time.

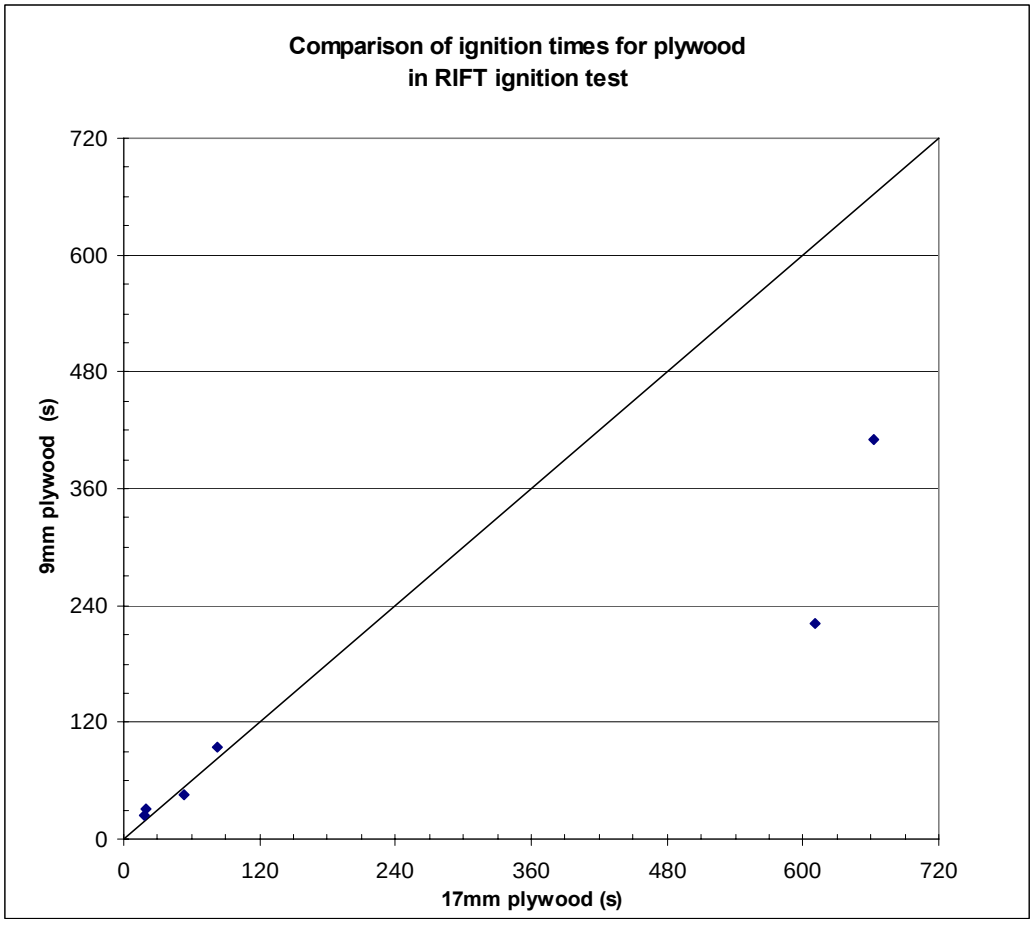



**Figure 154: Comparison of ignition times for plywood in RIFT test**

### *10.4 Proposal for improved apparatus*

The objective of this research report was to investigate alternative methods to the ASTM LIFT for measuring flame spread properties. While the RIFT shows some success, the limitation on suitable materials in order to get sufficient and consistent flame spread data rules out the use of the RIFT for a lot of cases.

During the fabrication and use of the LIFT, it became apparent that it would be possible to reduce the size and cost of the apparatus and increase the control of the radiant panel by using modern elements and thermocouple controllers.

The flux profile over the first 150mm of the sample is almost constant, allowing the LIFT to be used ignition testing. If this section was eliminated, then the length of the sample can be reduced without reducing the resolution of the flame spread section. This can be achieved by changing the offset of the panel to the sample so that the level section of the flux profile is shorter. The panel size can therefore also be reduced. The ignition tests can still be done if the radiant panel can turn to be parallel with the face of the sample, and is on a slide, similar to the University of Canterbury LIFT, so that the spacing between the sample and the elements can be changed.

The major change would be to use thermocouple controlled radiant electric elements. These are capable of reaching 1000°C within 3 minutes and give a black body radiant spectrum. The thermocouple controllers will give an output with far less variation than that of the gas panel, and the temperature across the face will be more uniform.

One limitation is that the electrical elements cannot produce the same output as the gas panel, with the current supply of 20A/phase giving $\dot{q}''_{50mm}$ = 50kW/m$^2$. This is primarily an issue for the ignition tests where higher heat fluxes are required. Having the element bank able to move closer to the sample will allow higher heat fluxes for ignition.

This should allow for a testing method which is only slightly bigger than the ISO 5657 ignition testing apparatus. This compares with the 1.7m*0.9m footprint of the LIFT testing apparatus.

The initial work is to make a full scale replacement of the LIFT gas panel, which can also be used as a reduced scale panel by eliminating some of the elements as required.

This allows the effect of scale to be determined, and would easily allow the use the current LIFT apparatus for direct comparison. The full scale radiant panel measures 490mm x 300mm and uses 15 Elstein SHTS elements. Each element measures 95mm square and is mounted at 100mm centres, and has a maximum continuous temperature of 900°C and an output of 800W. This would give a $\dot{q}''_{50mm}$ = 56kW/m$^2$ at the standard LIFT layout, as shown in Appendix 2.

# 11 Comparison of data with published literature

There is little published data available from LIFT flame spread tests, reflecting the narrower focus of the test when compared to the cone calorimeter. As can be seen from the results, the variations between nominally similar materials can be significant if the preheating time is not adequate to get the material to equilibrium before ignition. Even within materials of the same type or source, the variation can be significant.

There is a greater availability of ignition data for materials, some of which is summarised in Babrauskas (2003). Again, nominally identical materials can give different results for the same properties, depending on the testing apparatus, procedure and correlations or ignition theory used (Babrauskas, 2003)

Comparisons have to be treated with caution, since apart from the materials used within the tests conducted for this report, they were not controlled. The materials often have a different base for the same nominal material. As an example the material basis is given as Douglas fir or Southern Pine for much of the literature which uses US construction plywood, and European plywood tests where the material details are specified are birch based. New Zealand plywood is generally Radiata Pine, other than specialty furniture and marine plywood.

There is little data on NZ native timbers, other than that published by Ngu (2002) and Henderson (1998). The complete list of thermal properties and comparisons is given in Appendix 5. The list of properties from the literature is limited to those approximately the same as those tested for this report, in regard to material composition and surface finish.

Not all the results can be compared, as much of the literature does not give the data for values such as $\dot{q}''_{ig,\min}$.

## *11.1 Comparison of Ignition results with published literature*

### 11.1.1 Thermal inertia ($k\rho c$)

The thermal inertia from the ignition tests generally compares well with the published data, as shown in Figure 155 - Figure 156 and Appendix 5

The thermal inertia plays a direct part in the flame spread calculation, given in equation (33). As can be seen from the results, there can be significant variation even with the same material, due to the correlations used and the effect of different testing methods. The detail of each material is given in Appendix 5 if it was specified in the original reference.

The round-robin test report by Fowell of the LIFT apparatus, reported that a 2:1 spread of results was not uncommon, despite testing the same material, using the same methods in different laboratories.

The thermal inertia for plywood could be expected to vary more than more homogeneous materials, due to the presence of voids in the material from bonding the ply. As this plywood was rated C/D grade, then some internal voids could be expected

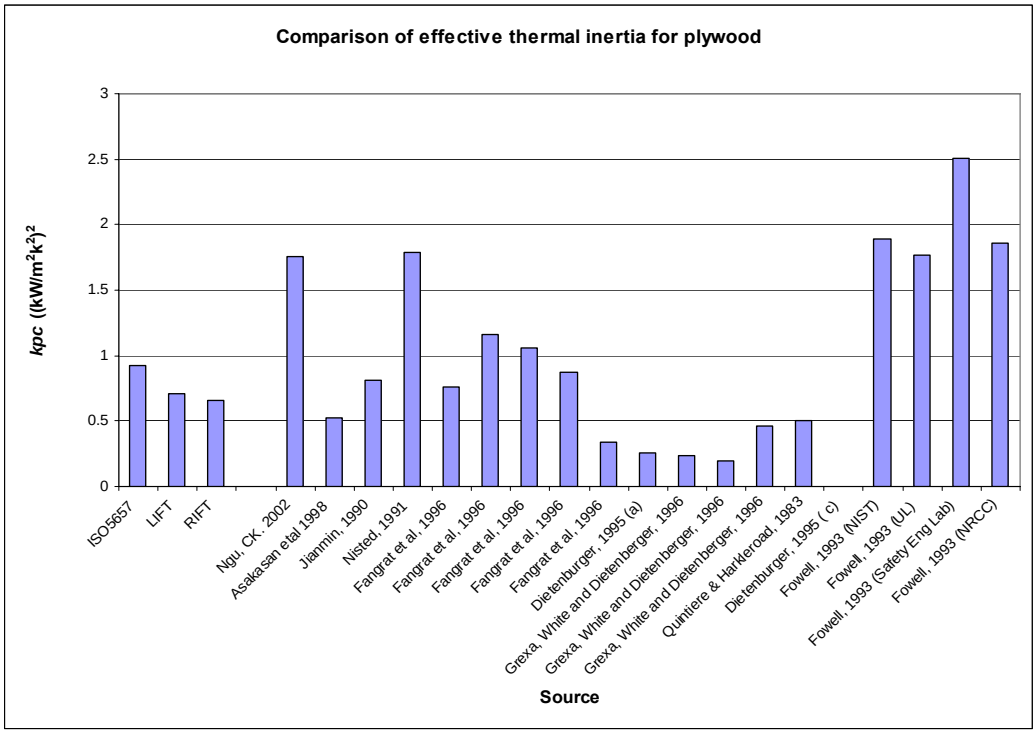



**Figure 155: Comparison of thermal inertia of plywood**

Particle board and fibreboard products, such as MDF and hardboard show much more consistent results than plywood, due to the more homogeneous nature of the material. Despite being made from the same base material, there is a significant difference between the thermal inertia of Pynefloor and Superflake particle board and between the results from different test methods on the same material.

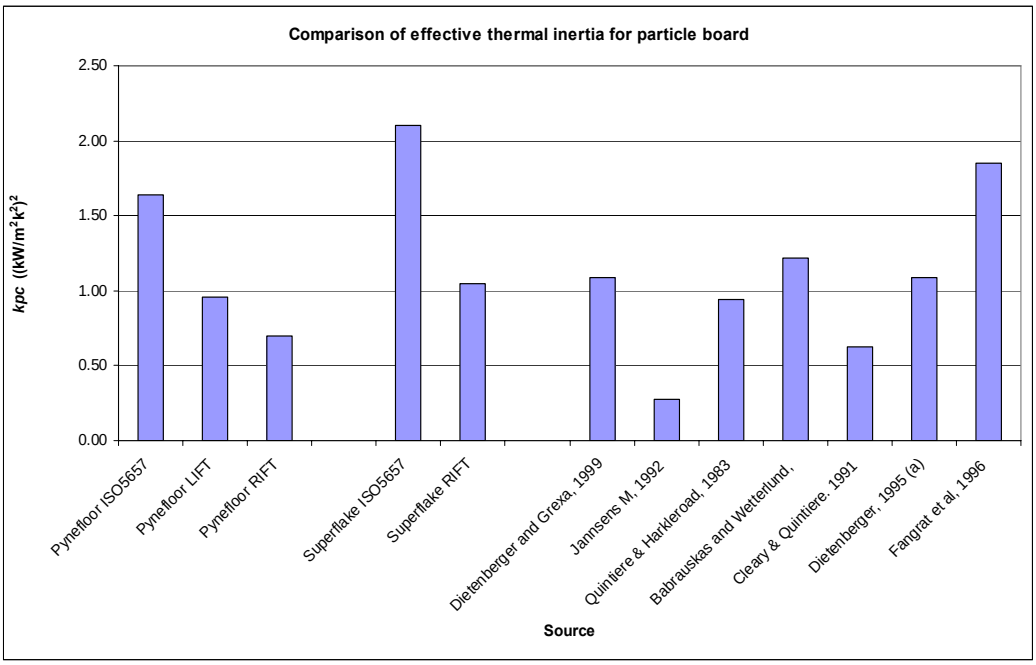



**Figure 156: Comparison of thermal inertia of particle board**

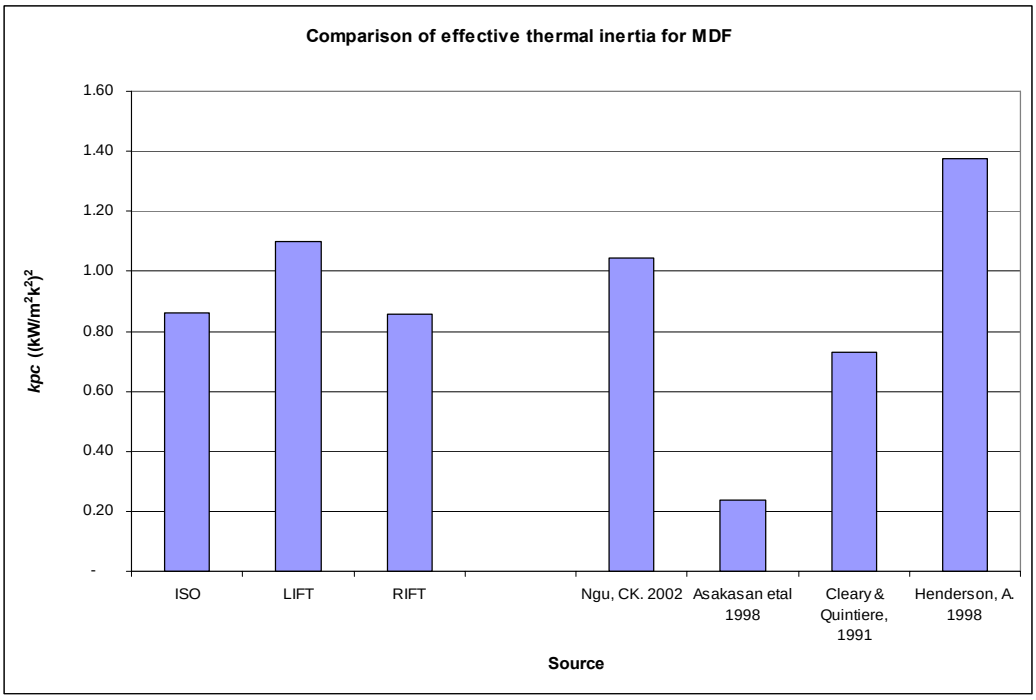



**Figure 157: Comparison of thermal inertia of MDF**

Since the definition of "hardboard" is not necessarily clearly defined, then some variation can be expected for this material (Figure 158). The results for Dietenberger come from a report on siding materials, so it may not be"hardboard" of the same type as tested in this report.

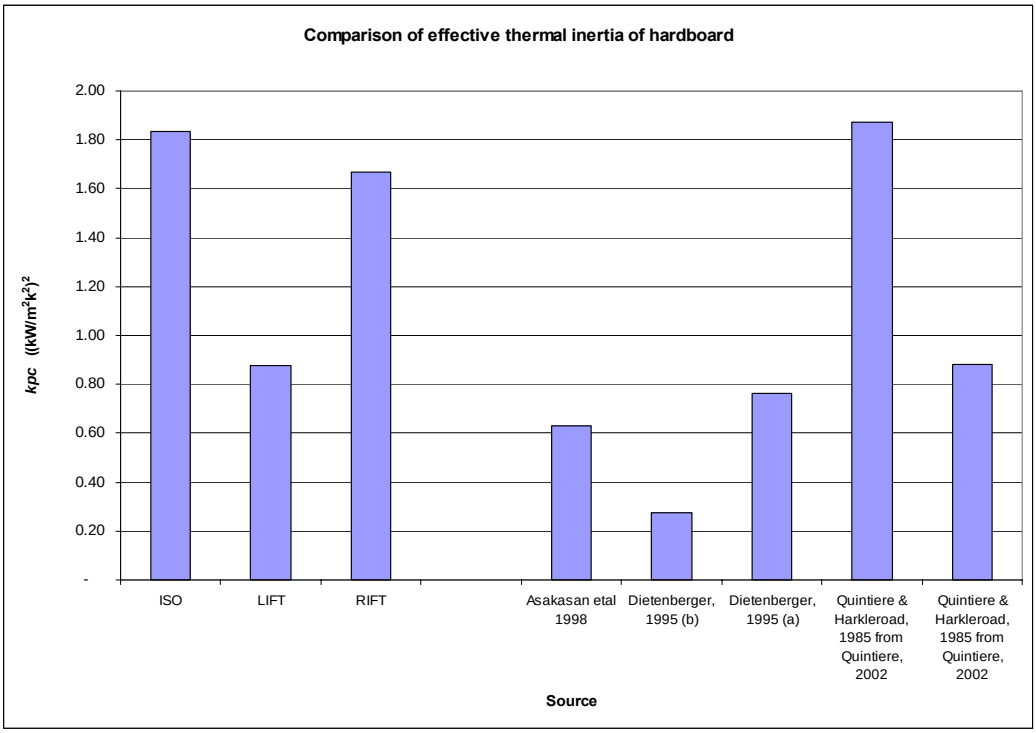



**Figure 158: Comparison of thermal inertia of hardboard**

When the thermal inertia for natural timbers is compared, there is much more variation.

The value for thermal inertia from Moghtaderi et al. (1997) for Radiata Pine, shown in Figure 159, is for US grown specimens at 15% moisture content. The others are for New Zealand grown Radiata Pine, and the results for Henderson (1998) were at 11% moisture content, and both were measured in the cone calorimeter.

Henderson (1998) got identical results for thermal inertia and ignition temperature for Rimu heart wood and sapwood, although the critical ignition flux was 20% higher for the heart wood over the sap wood.

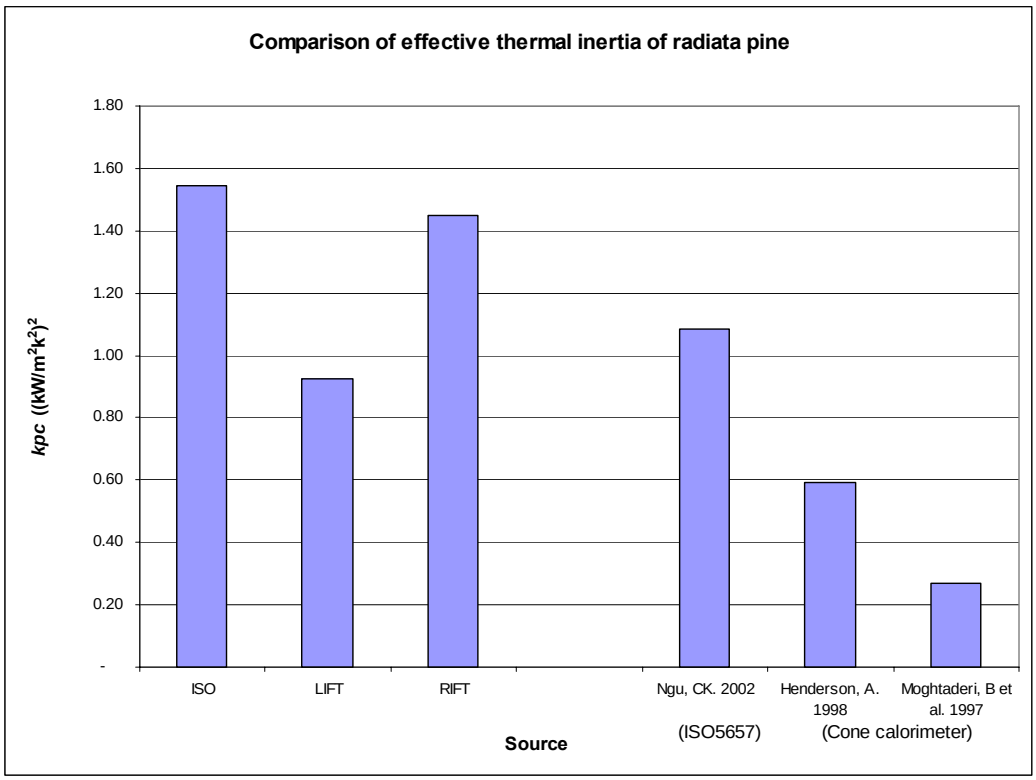



**Figure 159: Comparison of thermal inertia of Radiata (Monterey) Pine**

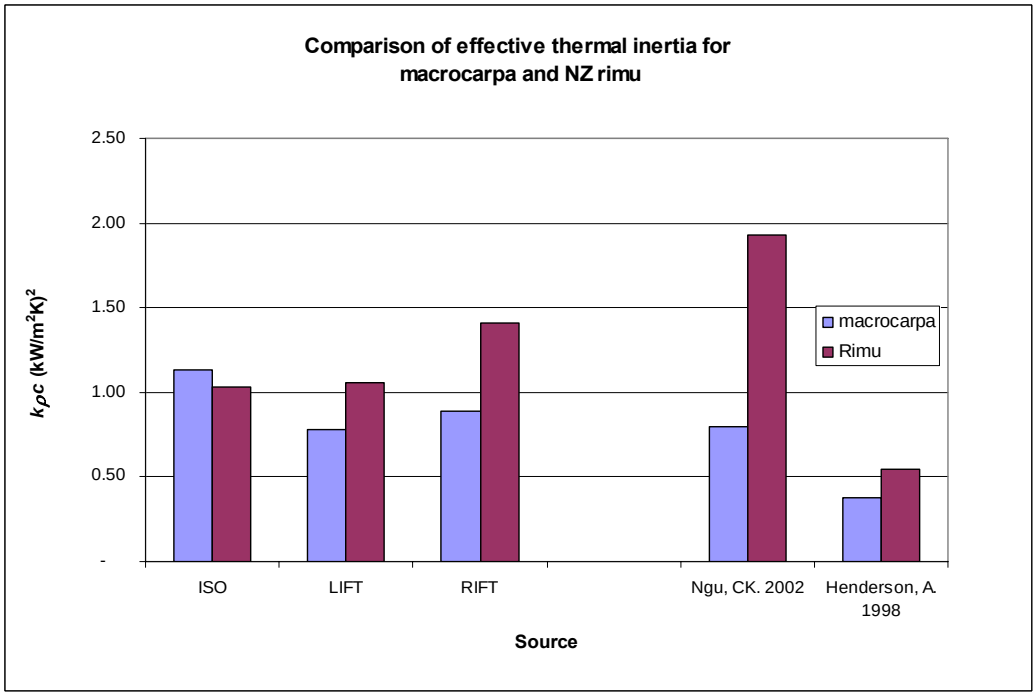



**Figure 160: Comparison of thermal inertial of Macrocarpa and NZ Rimu**

## *11.2 Comparison of published flame spread results*

The significant effect of preheating on the results for the flame spread parameter has been covered previously in Section 10.3.1.

The results from Huynh (2003) should be taken with care, as the correlation obtained by Huynh of the flame spread results was poor, and the material was not preheated.

The results from Jinmen (1990) was calculated using the data given in the report by Jinmen as the flame spread parameter was not specifically stated as an outcome.

### 11.2.1 Flame spread parameter

The results for plywood show that the flame spread parameter results in these tests on New Zealand Radiata based plywood are generally higher than the published values in the literature for plywood.

The non-preheated results in the RIFT are comparable with those obtained by Huynh (2002), who also used Radiata pine plywood without preheating.

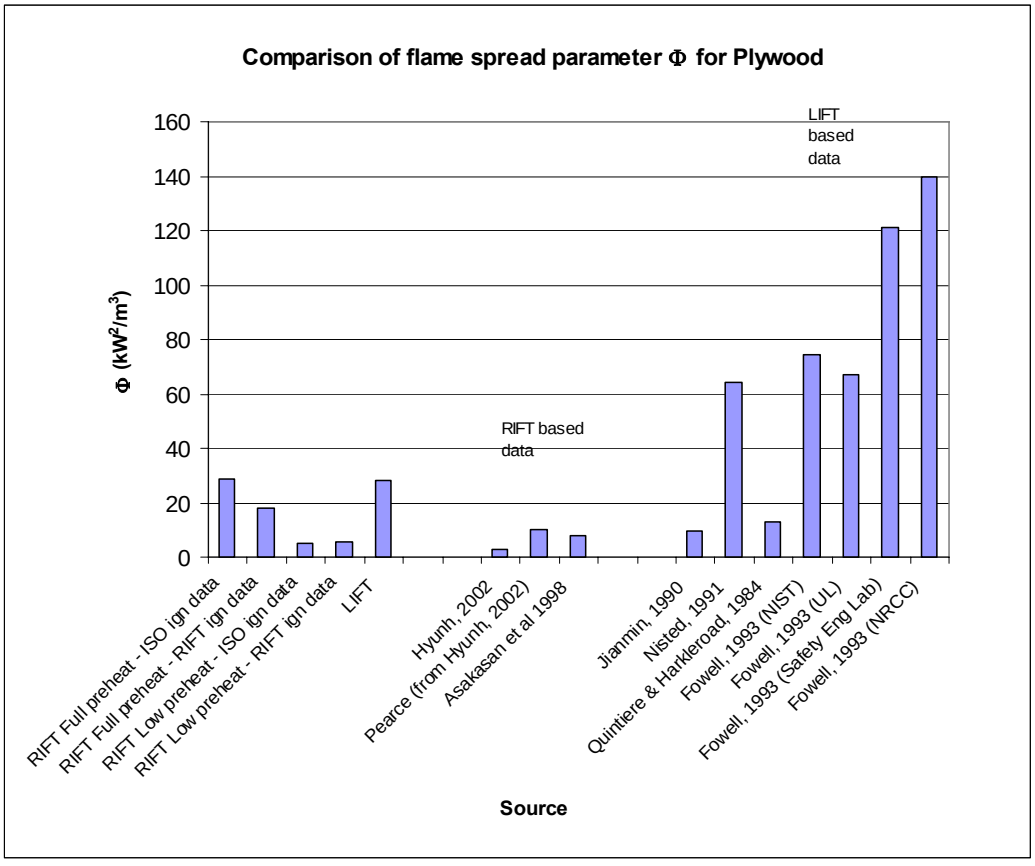



**Figure 161: Flame spread parameter for plywood**

The results for medium density fibreboard (Figure 162) show that the flame spread parameter for this material is greatly affected by the preheating time. Fibreboard is an ill-defined material, as it can cover a range of materials made from wood fibre, including low density ceiling panel material as wall as medium and high density fibreboard, and the material specified as "fibreboard" by Azhakesan et al (1998) is not clearly defined as MDF. No density information was available in the original publication, and a comment was made that the value they obtained was lower than expected, and this value was expected to be around 13 $kW^2/m^3$.

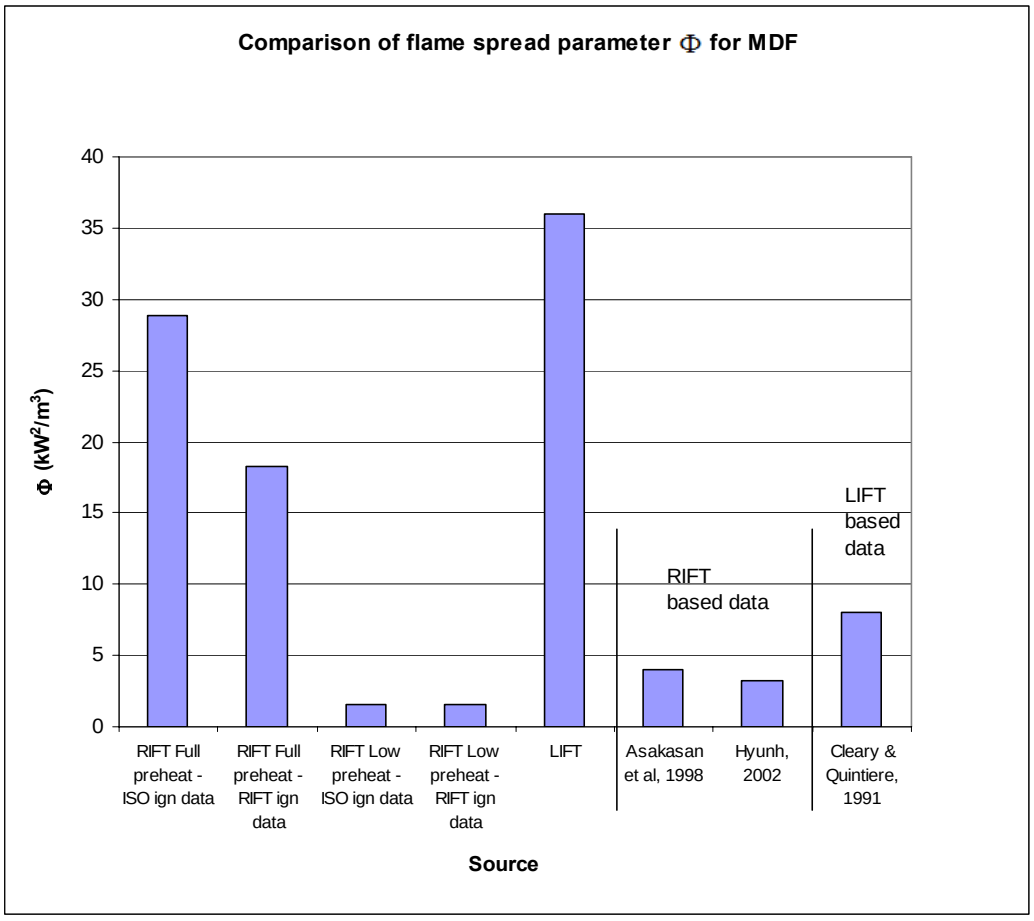



**Figure 162: Comparison of flame spread parameter for MDF**

Particle board is a commonly tested material in the LIFT literature, and much of the initial work on developing the theory was based on results for this material (Quintiere et al, 1981, 1983, 1984)

The results for the RIFT are similar to the published data, but significantly less than the results from the LIFT with the same material.

The results for a low preheating period are similar to Huynh (2002), which were also not preheated.

The particle board used by Cleary (1991), Quintiere and Harkleroad (1984) and Babrauskas (1999) were Douglas Fir based, as opposed to the results from these tests, and Huynh (2002), which were all Radiata Pine based.

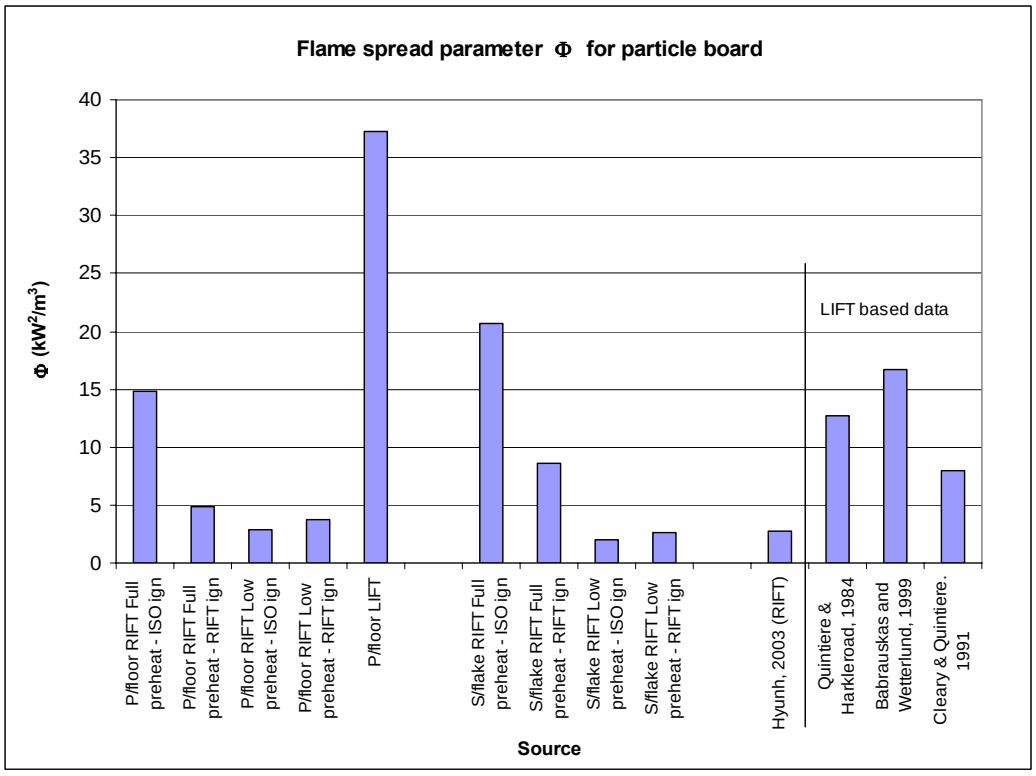



**Figure 163: Flame spread parameter for particle board**

# 12 Conclusions

A full-scale ASTM E 1321 Lateral ignition and Flame Transport (LIFT) apparatus was constructed and a reduced scale ignition and flame spread apparatus (RIFT) was built to fit the cone calorimeter in the vertical position. A series of lateral flame spread tests with 9 different types of timber based products were conducted, and Quintiere's flame spread model was applied to the results to obtain material properties. These materials included plywood, medium density fibreboard (MDF), hardboard, particle board flooring, Melteca covered MDF, Radiata Pine, NZ Rimu, Macrocarpa and New Zealand Beech. Further limited tests were conducted on Melteca covered particle board, and a second brand of particle board.

As only timber based products were tested, the conclusions regarding the suitability of the RIFT can only be in relation to these materials. Other materials may give different results from those obtained in these tests.

*Test methodology*

These tests were based on the procedures given in the ASTM standard, and were conducted using common materials with both sets of equipment, so the results could be compared. Ignition tests were conducted in the LIT, RIFT and ISO 5657 ignitability apparatus. The flame spread tests in the RIFT were done with a preheating period, as required by the ASTM standard, and also without the preheating period, to gauge the effect of preheating on the results.

*The effect of sample preheating*

If the sample was not preheated to equilibrium before the flame spread test, the resulting values for the flame spread parameter are lower than with a fully preheated sample. This reflects the lower flame front velocity across the sample due to the greater difference between the surface temperature and the material ignition temperature. Non preheated samples also had more scatter in the correlation results, and the extent of flame spread was less than for preheated samples, if the flame spread was faster than the material in ahead of the flame front could reach equilibrium. This gives a higher value for the heat flux required for flame spread ($\dot{q}''_s$) than is actually

achievable, hence in a fire situation, where some preheating can be expected, the flame front will spread further than anticipated.

For comparable values to the LIFT, the testing method must be the same, so preheating is required in the RIFT in the same manner as the LIFT results.

*The reduced scale flame test method*

The RIFT method of flame spread testing has been shown to be successful for measuring flame spread properties; however, there are limitations on materials which can be reliably tested. These limitations are dictated by the smaller scale, such that the effects of errors on the results are more pronounced. The shape of the flux distribution profile along the sample has a sharp decay due to the directionality of the cone element, which leads to insufficient flame spread for accurate results for materials where the flux required for flame spread $\dot{q}''_s$ >7kW/m$^2$. This equates to a maximum limit in the minimum flux for ignition $\dot{q}''_{ig,\min}$ of 18-19 kW/m$^2$, although this limit is not clearly defined. It was not possible to get flame spread results for Rimu, yet Macrocarpa gave acceptable results, despite both materials having the same value of $\dot{q}''_{ig,\min}$.

Allied to the limitation of suitable materials dictated above, the material behaviour during flame spread is more critical. The smaller scale increases the effect of errors and erratic burning behaviour. The tests for Melteca covered MDF showed that the erratic behaviour caused buy the Melteca facing meant that no reliable correlation was possible in the RIFT, even though a result was obtained in the LIFT.

Using the RIFT for the ignition tests proved to give inconsistent results and this most likely due to the design of the apparatus, which disrupts the airflow over the face of the sample. The ignition results which gave the best results when combined with the RIFT flame spread data came from the tests in the ISO 5657 ignitability apparatus.

A view factor calculation was developed for the RIFT, based on earlier work by Huynh (2002), and compared against experimental findings. The simplifications in the view factor model led to results than were consistently to low against the experimental findings, although the match of the shape of the resulting curve was good.

*Flame spread parameter*

The LIFT gives values for the ignition parameter "*b*", used in calculating the flame spread parameter values, which are generally higher than those obtained in the ISO 5657 ignition test, leading to higher values for the flame spread parameter $\Phi$ for similar flame spread test results.

The flame spread parameter $\Phi$ calculated from the results in the RIFT, using the ISO ignition data is generally comparable to those obtained in the LIFT, although on average, the value tends to be higher than the value obtained in the LIFT. The more erratic ignition results for ignition tests in the RIFT give a wide variation in the flame spread parameter results, and this ignition method is not recommended.

The values for the minimum flux for heat spread are comparable between the RIFT and the LIFT, for values which are under the recommended limit for successful RIFT tests.

Ignition tests in the ISO 5657 apparatus generally gave faster times to ignition than the same material in the LIFT, with a difference of 4% overall. This difference is expected, but the magnitude of the difference is less than other tests in the literature. To get a more definitive result would require more ignition tests.

Generally, the flame spread correlation gave the expected results for the minimum ignition flux against the experimental values. The correlated value is higher than the experimental values, in line with the findings of Quintiere et al, 1983.

*The University of Canterbury LIFT apparatus and future developments*

This report also gives the first results of the new LIFT testing machine, built at the University of Canterbury in the first half of 2005. After initial teething problems, it has proven to give a consistent output. The burner is running on LPG, rather than methane, originally specified in the ASTM standard, due to problems with supply of methane or natural gas.

Due to the limitations imposed by LPG on the lowest flux levels possible by the burner, the burner position is adjustable using a 7/8" leadscrew to allow the burner to be positioned further away from the sample for lower flux levels during ignition tests. This has proven to be successful, achieving a minimum flux level at the sample face of 11kW/m$^2$, and the lead screw allows for consistent positioning and fine adjustment.

The current air supply limits the burner output to a maximum sustained output of 50kW/$m^2$ at the sample face, although tests have shown that over 60kW/$m^2$ is possible if the air supply is available.

A modification to the design is proposed, using a thermocouple controlled radiant electric panel instead of the gas burner, which will give a more consistent output, and greater control than the gas panel can provide. Allied to this is a proposed intermediate/ bench scale test apparatus, which will give the same sample resolution and flame spread testing flux profile, yet allow the use of a smaller and less expensive apparatus than the current LIFT.

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# Appendix 1: Procedure for operating University of Canterbury LIFT

The gas supply to the main radiant panel is controlled by a mass flow controller, and the compressed air supply is adjusted through an air regulator and ball valve (Figure 164). The ball valve allows the regulator to be used in the optimum range by providing a bulk adjustment to the output restriction. Without the ball valve set to give a minimum of 6-8 psi on the gauge, the regulator will fluctuate. The limiting flux output without preloading the regulator is where $\dot{q}''_{50mm}$ < approximately 26kW/m$^2$. Closing the ball valve part way loads up the regulator to 6-8psi and gives a stable output.

The pilot burner uses a mass flow controller for the air supply, and a separate LPG supply.

*Starting the LIFT panel*

- Insert the measurement template into the sample holder and fit the flux gauge in the 50mm position, so the face of the flux gauge is level and parallel with the face of the template.
- Turn on the water supply to the flux gauge.
- Close the ball valve so the air is turned off.
- Turn on gas and ignite the panel and set the gas output to the desired value on the mass flow controller by adjusting the set point adjustment (Figure 165).
- Slowly open the ball valve and adjust the air supply with the regulator and ball valve so that the regulator reads a minimum of 8 psi. Leave the mixture slightly rich, shown by the yellow flame tips, until the temperature and flux output has stabilised. As the burner heats up, it tends towards a leaner gas mixture and can flash back inside the burner.

Adjustments are made by either increasing the gas flow or decreasing the air so that gas mixture is rich during the flux alteration, so it doesn't flash back inside the burner. Once the burner is stable, which usually takes around 5 minutes, then the gas mixture can be adjusted for a neutral mix. Monitor the flux meter for a further time of approximately 5 minutes to ensure that it is stable.

Extinguish the radiant panel by turning off the air supply first and then the gas supply

**Figure 164: Regulator and ball valve.**

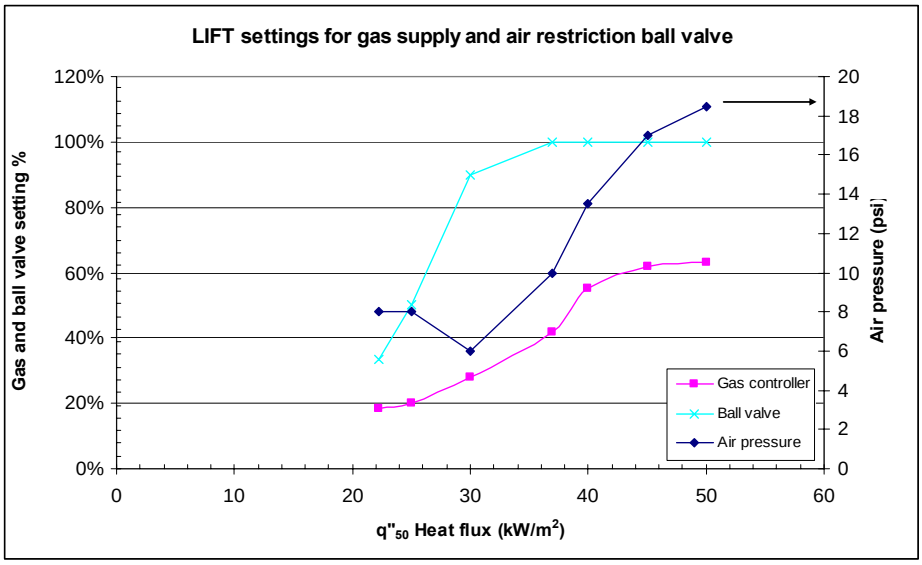


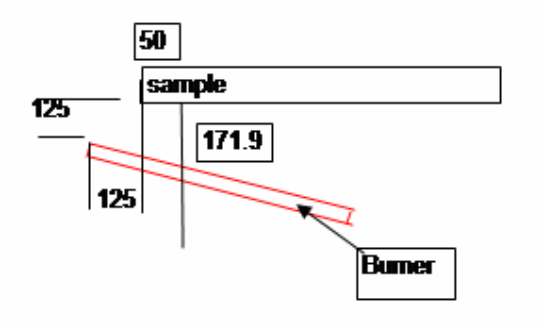

**Figure 165: LIFT settings**

*Setting the pilot flame*

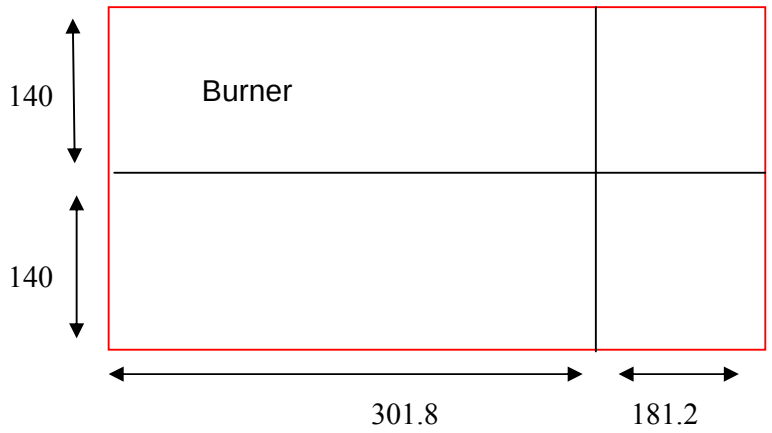
Set the air supply flow rate to minimum and turn off the pilot air supply mass flow controller and turn on the pilot burner gas supply and ignite the pilot flame. Turn on the air supply and adjust the gas needle valve and regulator and air supply to give a blue pilot flame approximately 180mm long. The flame mixture usually has to be slightly rich to be stable with the air turbulence during an ignition test. Once the pilot flame is set, further adjustment is not usually required.

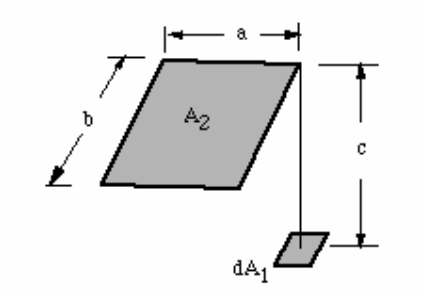
Appendix 2: Electrical power and current requirements for an electric LIFT radiant panel

| | | |
|---|---|---|
| Angle of sample to element | 15 | deg |
| Flux at 50mm point on sample | 50.5 | kW/m$^2$ |




Standard LIFT panel dimensions:






$$F_{d1-2} = \frac{1}{2\pi}\left\{\frac{A}{\left(1+A^2\right)^{1/2}}\tan^{-1}\left[\frac{B}{\left(1+A^2\right)^{1/2}}\right] + \frac{B}{\left(1+B^2\right)^{1/2}}\tan^{-1}\left[\frac{A}{\left(1+B^2\right)^{1/2}}\right]\right\}$$

*From: Howell, http://www.me.utexas.edu/~howell/index.html*

Area of panel segment (in line with 50mm point)

| | | |
|---|---|---|
| A1 = A2 | 0.042252 | $m^2$ |
| a3=a4 | 0.025368 | $m^2$ |
| Panel width | 0.28 | m |
| Panel length | 0.483 | m |
| Element temp | 1140.5 | K |
| | | |
| Stefan-Boltzman const. σ | 5.67E-08 | $Wm^2/K^4$ |
| Emissivity ε | 0.99 | (from Wilson et al for a cone calorimeter element) |

$\dot{q}''_{A1:A2}$ =F. σε.$(T)^4$

| | | |
|---|---|---|
| a | 0.140 | m |
| b | 0.302 | m |
| c | 0.172 | m |

| | | | |
|---|---|---|---|
| $F_{(A1,A2)}$ (View factor) | 0.147 | | |
| $\dot{q}''_{A1:A2}$ | 13979 | $W/m^2$ | |
| $\dot{q}''_{A3:A4)}=F.\sigma\varepsilon(T)^4$ | | | |
| a | 0.14 | m | |
| b | 0.181 | m | |
| c | 0.172 | m | |
| $F_{(A3,A4)}$ (View factor) | 0.128 | | |
| $\dot{q}''_{A3:A4}$ | 12143 | $W/m^2$ | |
| $\dot{q}''_{e}=$ | 52243 | | |
| Radiation received at point (angled 15 deg) | 50463 | $W/m^2$ | received at point |
| Radiation on sample | 50.5 | $kW/m^2$ | at 50mm sampling point |
| Element emitted heat flux | 95.0 | $kW/m^2$ | emitted from surface of element |
| Element area | 0.135 | $m^2$ | |
| Element power | 12.8 | kW | |
| current (240v) | 54 | Amps | if electrically powered at 240v |

# Appendix 3: Results of material tests

## *Ignition test results*

| **MDF – 18mm** | LIFT | ISO 5657-1986 | Ngu (ISO 5657) | Ignition in RIFT | |
|---|---|---|---|---|---|
| Ignition parameter *b* | 0.047 | 0.053 | 0.043 | 0.053 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 21 | 19 | 23 | 19 | $s^{0.5}$ |
| Preheat time t* | 456 | 355 | 544 | 357 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 3.4 | 3.7 | 4.7 | -0.3 | $kW/m^2$ |
| Thermal inertia *kpc* | 1.10 | 0.86 | 1.04 | 0.86 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 16.25 | 16.25 | 13.5 | 16.25 | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | 0.044 | 0.044 | 0.039 | 0.043 | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | 391 | 391 | 348 | 391 | °C |
| | | | | | |
| **Plywood - 17mm** | LIFT | ISO 5657-1986 | Ngu (ISO 5657) | Ignition in RIFT | |
| Ignition parameter *b* | 0.058 | 0.048 | 0.034 | 0.061 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 17 | 21 | 29 | 17 | $s^{0.5}$ |
| Preheat time t* | 293 | 432 | 870 | 273 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 7.2 | 4.6 | 7.2 | 9.9 | $kW/m^2$ |
| Thermal inertia *kpc* | 0.71 | 0.93 | 1.76 | 0.66 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{crit}$ | 16.3 | 13.8 | 12.0 | 16.3 | $kW/m^2$ |

| | | | | | |
|---|---|---|---|---|---|
| Heat transfer coefficient at ignition *h* | 0.044 | 0.041 | 0.040 | 0.043 | kW/m$^2$K |
| Ignition temperature $T_{ig}$ | 391 | 352 | 321 | 391 | °C |
| | | | | | |
| **Melteca faced MDF** | LIFT | ISO 5657-1986 | Ignition in RIFT | | |
| Ignition parameter *b* | 0.0423 | 0.0429 | 0.051 | | s$^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 24 | 23 | 19.5 | | s$^{0.5}$ |
| Preheat time t* | 560 | 542 | 382 | | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | -6.44 | 2.58 | 1.06 | | kW/m$^2$ |
| Thermal inertia *kpc* | 1.475 | 1.474 | 1.07 | | (kW/m$^2$K)$^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 18.75 | 20 | 21.25 | | kW/m$^2$ |
| Heat transfer coefficient at ignition *h* | 0.045 | 0.046 | 0.047 | | kW/m$^2$K |
| Ignition temperature $T_{ig}$ | 440 | 425 | 454 | | °C |
| | | | | | |
| **Melteca/ Particle board** | LIFT | ISO 5657-1986 | Ignition in RIFT | | |
| Ignition parameter *b* | Not tested | 0.044 | 0.057 | | s$^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | Not tested | 22.6 | 17.5 | | s$^{0.5}$ |
| Preheat time t* | Not tested | 512 | 308 | | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | Not tested | 2.00 | 10.1 | | kW/m$^2$ |
| Thermal inertia *kpc* | Not tested | 1.27 | 0.97 | | (kW/m$^2$K)$^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | Not tested | 18.75 | 23.75 | | kW/m$^2$ |
| Heat transfer coefficient at ignition *h* | Not tested | 0.044 | 0.050 | | kW/m$^2$K |
| Ignition temperature $T_{ig}$ | Not tested | 425 | 478 | | °C |
| | | | | | |

| | | | | |
|---|---|---|---|---|
| **Pynefloor particle Board** | LIFT | ISO 5657-1986 | | |
| Ignition parameter *b* | 0.0509 | 0.0364 | 0.063 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 19.6 | 27.5 | 16 | $s^{0.5}$ |
| Preheat time t* | 385.6 | 754.6 | 250 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 1.7 | 3.5 | 4.3 | $kW/m^2$ |
| Thermal inertia *kpc* | 0.96 | 1.64 | 0.70 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 18.75 | 13.75 | 21.25 | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | 0.044 | 0.041 | 0.047 | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | 425 | 352 | 454 | °C |
| | | | | |
| **Superflake particle board** | LIFT | ISO 5657-1986 | Ignition in RIFT | |
| Ignition parameter *b* | Not tested | 0.0327 | 0.05 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | Not tested | 30.6 | 19.72 | $s^{0.5}$ |
| Preheat time t* | Not tested | 935 | 389 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | Not tested | 3.44 | 5.24 | $kW/m^2$ |
| Thermal inertia *kpc* | Not tested | 2.11 | 1.05 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | Not tested | 13.75 | 18.75 | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | Not tested | 0.042 | 0.05 | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | Not tested | 352 | 424.87 | °C |
| | | | | |

| **Hardboard** | LIFT | ISO 5657-1986 | Ignition in RIFT | | |
|---|---|---|---|---|---|
| Ignition parameter *b* | 0.052 | 0.033 | 0.032 | | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 19 | 31 | 31.3 | | $s^{0.5}$ |
| Preheat time t* | 375 | 944 | 977 | | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 2.172 | - 0.588 | 2.6 | | $kW/m^2$ |
| Thermal inertia *kpc* | 0.88 | 1.83 | 1.67 | | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 17.5 | 11.25 | 11.25 | | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | 0.043 | 0.039 | 0.037 | | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | 409 | 307 | 307 | | °C |
| | | | | | |
| **NZ Beech** | LIFT | ISO 5657-1986 | Ngu (ISO 5657) | Ignition in RIFT | |
| Ignition parameter *b* | 0.050 | 0.053 | 0.025 | 0.034 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 20 | 19 | 40 | 29.1 | $s^{0.5}$ |
| Preheat time t* | 395 | 355 | 1,618 | 844 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 9.24 | 11.83 | 11.14 | 12.8 | $kW/m^2$ |
| Thermal inertia *kpc* | 0.98 | 0.85 | 3.27 | 2.30 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 18.75 | 18 | 12 | 18.75 | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | 0.044 | 0.043 | 0.040 | 0.046 | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | 425 | 415 | 321 | 425 | °C |
| | | | | | |

| **Radiata Pine** | LIFT | ISO 5657-1986 | Ngu (ISO 5657) | Ignition in RIFT | |
|---|---|---|---|---|---|
| Ignition parameter *b* | 0.054 | 0.039 | 0.047 | 0.043 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 18 | 25 | 21 | 23 | $s^{0.5}$ |
| Preheat time t* | 341 | 643 | 460 | 531 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 9.7 | 12.0 | 7.8 | 10.9 | $kW/m^2$ |
| Thermal inertia *kpc* | 0.92 | 1.54 | 1.08 | 1.45 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 18.75 | 16.25 | 15.5 | 18.75 | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | 0.046 | 0.043 | 0.043 | 0.046 | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | 425 | 391 | 380 | 425 | °C |
| | | | | | |
| **Rimu** | LIFT | ISO 5657-1986 | Ngu (ISO 5657) | Ignition in RIFT | |
| Ignition parameter *b* | 0.050 | 0.050 | 0.033 | 0.047 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 20 | 20 | 30 | 21.5 | $s^{0.5}$ |
| Preheat time t* | 395 | 397 | 893 | 462 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 9.62 | 12.75 | 7.52 | 13.9 | $kW/m^2$ |
| Thermal inertia *kpc* | 1.06 | 1.03 | 1.93 | 1.41 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 18.5 | 18 | 13.5 | 21.25 | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | 0.046 | 0.045 | 0.041 | 0.049 | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | 422 | 415 | 348 | 454 | °C |
| | | | | | |

| **Macrocarpa** | LIFT | ISO 5657-1986 | Ngu (ISO 5657) | Ignition in RIFT | |
|---|---|---|---|---|---|
| Ignition parameter *b* | 0.059 | 0.048 | 0.055 | 0.056 | $s^{0.5}$ |
| intercept of ignition parameter graph $(t^*)^{0.5}$ | 17 | 21 | 18 | 18.0 | $s^{0.5}$ |
| Preheat time t* | 288 | 436 | 337 | 325 | sec |
| Critical ignition flux $\dot{q}''_{crit}$ | 14.7 | 15.2 | 12.9 | 15.6 | $kW/m^2$ |
| Thermal inertia *kpc* | 0.78 | 1.13 | 0.79 | 0.89 | $(kW/m^2K)^2$ |
| Minimum ignition flux $\dot{q}''_{ig,\min}$ | 18.75 | 18 | 15.5 | 18.75 | $kW/m^2$ |
| Heat transfer coefficient at ignition *h* | 0.046 | 0.045 | 0.043 | 0.046 | $kW/m^2K$ |
| Ignition temperature $T_{ig}$ | 425 | 415 | 380 | 425 | °C |

*Ignition test data*

**Plywood - 17mm**

| ISO 5657 | | RIFT | | LIFT | |
|---|---|---|---|---|---|
| Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) |
| 10 | no ignition | 12.5 | No ign | 12.5 | No ign |
| 12.5 | 1690 | 15 | No ign | 15 | No ign |
| 15 | 1125 | 17.5 | 663 | 17.5 | 760 |
| 20 | 229 | 20 | 611 | 20 | 173 |
| 30 | 69 | 30 | 82 | 30 | 114.7 |
| 40 | 49 | 40 | 52.8 | 40 | 42.4 |
| 50 | 28.7 | 50 | 19.5 | 50 | 26 |
| 60 | 23.3 | 60 | 18.5 | | |

**Medium Density fibreboard (MDF)**

| ISO 5657 | | RIFT | | LIFT | |
|---|---|---|---|---|---|
| Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) |
| 15 | no ignition | 17.5 | 343 | 15 | No ign |
| 17.5 | 723 | 20 | 215 | 17.5 | 760 |
| 20 | 239 | 30 | 92 | 20 | 173 |
| 30 | 101 | 40 | 60.5 | 30 | 114.7 |
| 40 | 56.4 | 50 | 30 | 40 | 42.4 |
| 50 | 39.2 | 60 | 28 | 50 | 26 |
| 60 | 25.4 | | | | |

**Melteca / MDF**

**ISO 5657**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 20 | No ign |
| 21 | 977 |
| 22.5 | 467 |
| 25 | 354 |
| 30 | 204 |
| 40 | 126 |
| 50 | 84 |
| 60 | 62 |

**RIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 20 | No ign |
| 22.5 | 349 |
| 30 | 188 |
| 40 | 108 |
| 50 | 58.1 |
| 60 | 53.4 |

**LIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 20 | 401 |
| 30 | 257 |
| 40 | 153 |
| 50 | 93.5 |

**Melteca / particle board shelving**

**ISO 5657**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 20 | 558 |
| 22.5 | 356 |
| 25 | 255 |
| 30 | 170 |
| 35 | 128 |
| 40 | 93 |
| 50 | 59 |
| 60 | 45.4 |

**RIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 22.5 | No ign |
| 25 | 292 |
| 30 | 221 |
| 40 | 95 |
| 50 | 54.2 |
| 60 | 30.2 |

**LIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| | Not tested |

**Pynefloor particle board**

**ISO 5657**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 12.5 | No ign |
| 15 | 1166 |
| 17.5 | 575 |
| 20 | 368 |
| 25 | 215 |
| 30 | 154 |
| 35 | 98 |
| 40 | 93 |
| 50 | 47 |
| 60 | 38.4 |

**RIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 20 | No Ign |
| 22.5 | 226 |
| 30 | 140 |
| 40 | 64.8 |
| 50 | 35 |
| 60 | 27.5 |

**LIFT**

| Heat flux (kW/m2) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 20 | 315 |
| 30 | 175 |
| 40 | 86.5 |
| 50 | 50.5 |

**Superflake particle board**

**ISO 5657**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 12.5 | No ign |
| 15 | 1090 |
| 17.5 | 525 |
| 20 | 333 |
| 25 | 210 |
| 30 | 128 |
| 35 | 88 |
| 40 | 75 |
| 50 | 48 |
| 60 | 31.4 |

**RIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 20 | 404 |
| 30 | 123 |
| 40 | 75 |
| 50 | 33 |
| 60 | 39.4 |

**LIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| | Not tested |

**Hardboard**

| ISO 5657 | | RIFT | | LIFT | |
|---|---|---|---|---|---|
| Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) |
| 10 | 1378 | 12.5 | 886 | 15 | 1403 |
| 12.5 | 712 | 15 | 605 | 17.5 | 1223 |
| 15 | 402 | 17.5 | 338 | 20 | 259 |
| 20 | 285 | 20 | 273 | 30 | 108.5 |
| 30 | 127 | 30 | 117 | 40 | 96 |
| 40 | 74 | 40 | 62 | 50 | 64.5 |
| 50 | 52 | 50 | 30 | | |
| 60 | 35 | 60 | 28.4 | | |

**Rimu**

| ISO 5657 | | RIFT | | LIFT | |
|---|---|---|---|---|---|
| Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) | Heat flux ($kW/m^2$) | Time to ignition (s) |
| 17.5 | No ign | 20 | No ign | 15 | 1549 |
| 18.5 | 1358 | 22.5 | 544 | 17.5 | 1308 |
| 20 | 1134 | 30 | 219.5 | 20 | 366 |
| 30 | 186 | 40 | 53 | 30 | 187.5 |
| 40 | 61 | 50 | 24.1 | 40 | 61 |
| 50 | 31.5 | 60 | 22.4 | 50 | 34.4 |
| 60 | 24 | | | | |

**Pine**

**ISO 5657**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 15 | No ign |
| 17.5 | 1154 |
| 18.5 | 982 |
| 20 | 586 |
| 30 | 109 |
| 40 | 43 |
| 50 | 21.3 |
| 60 | 16.6 |

**RIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 20 | 660 |
| 30 | 96.6 |
| 40 | 37 |
| 50 | 16.9 |
| 60 | 17.5 |

**LIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s)) |
|---|---|
| 15 | 1490 |
| 17.5 | 1348 |
| 20 | 331 |
| 30 | 131 |
| 40 | 61 |
| 50 | 29.5 |

**Macrocarpa**

**ISO 5657**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 18.5 | 1767 |
| 20 | 1077 |
| 30 | 237 |
| 40 | 32.5 |
| 50 | 14.2 |
| 60 | 15.9 |

**RIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 20 | 976 |
| 30 | 182 |
| 40 | 43.6 |
| 50 | 14.3 |
| 60 | 15.4 |

**LIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s)) |
|---|---|
| 17.5 | No ign |
| 20 | 1439 |
| 30 | 114 |
| 40 | 74.5 |
| 50 | 26 |

**NZ Beech**

**ISO 5657**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | glowing at 1800 |
| 18.5 | 1526 |
| 20 | 774 |
| 30 | 162 |
| 40 | 52.8 |
| 50 | 35 |
| 60 | 23 |

**RIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 20 | No ign |
| 22.5 | 901 |
| 30 | 104 |
| 40 | 33.5 |
| 50 | 15.2 |
| 60 | 19.5 |

**LIFT**

| Heat flux ($kW/m^2$) | Time to ignition (s) |
|---|---|
| 17.5 | No ign |
| 20 | 366 |
| 30 | 176.4 |
| 40 | 62.5 |
| 50 | 33.2 |

# Appendix 4 Flame spread results

## *12.1 Summary of flame spread results*

| **Plywood** - | *RIFT (using RIFT ignition data) - 17mm* | *RIFT (using ISO ignition data) - 17mm* | *RIFT (using RIFT ignition data) - 17mm* | *RIFT (using ISO 5657 ignition data) - 17mm* | *LIFT* |
|---|---|---|---|---|---|
| - | low preheat time | low preheat time | Full preheat time | Full preheat time | Full preheat time |
| Flame spread modulus *C* | 7.74 | 10.72 | 4.37 | 4.37 | 3.7 |
| Flame spread parameter $\Phi$ | 5.80 | 4.79 | 18.23 | 28.84 | 28.0 |
| $q''_{ig,\min}$ (ignition test) | 16.25 | 13.75 | 16.25 | 13.75 | 16.3 |
| $q''_{ig,\min}$ (correlation) | 16.46 | 12.83 | 20.23 | 20.23 | 21.6 |
| $q''_{s}$ (correlation) | 5.25 | 5.25 | 4.62 | 4.62 | 5.4 |
| $q''_{s}$ ( from extent of flame spread) | 6.47 *Std Dev 1.32* | 6.47 *Std Dev1.32* | 4.74 *Std Dev0.33* | 4.74 *Std Dev 0.33* | 5.3 *Std Dev 0.65* |

| **Medium Density Fibreboard (MDF)** | *RIFT - 18mm MDF with ISO ign data* | *RIFT - 18mm MDF with RIFT ignition data* | *RIFT - 18mm MDF with ISO ign data* | *RIFT - 18mm MDF with RIFT ignition data* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheating time | Low preheating time | Full preheating time | Full preheating time | Full preheating time |
| Flame spread modulus *C* | 17.01 | 17.10 | 4.9 | 4.9 | 4.0 |
| Flame spread parameter $\Phi$ | 1.56 | 1.55 | 18.6 | 18.5 | 36.0 |
| $q''_{ig,\min}$ (ignition test) | 16.25 | 16.25 | 16.3 | 16.3 | 16.3 |
| $q''_{ig,\min}$ (correlation) | 14.85 | 14.82 | 24.3 | 24.3 | 23.6 |

| | | | | | |
|---|---|---|---|---|---|
| $q''_s$ (correlation) | 8.67 | 8.67 | 6.7 | 6.7 | 6.0 |
| $q''_s$ ( from extent of flame spread) | 8.23<br>*Std Dev 0.26* | 8.23<br>*Std Dev 0.26* | 6.3<br>*Std Dev0.2* | 6.3<br>*Std Dev 0.2* | 5.9<br>*Std Dev 0.4* |
| **Melteca faced Particle board** | *RIFT (using ISO 5657 ignition data* | *RIFT (Using RIFT ign data* | *RIFT (Using RIFT ign data* | *RIFT (Using ISO 5657 ign data* | *LIFT* |
| | Low preheat time | Low preheat time | Full preheat time | Full preheat time | Full preheat time |
| Flame spread modulus *C* | 2.76 | 2.72 | 1.78 | 1.78 | Not tested |
| Flame spread parameter $\Phi$ | 90.72 | 65.54 | 154.28 | 206.73 | Not tested |
| $q''_{ig,\min}$ (ignition test) | 18.75 | 23.75 | 23.75 | 18.75 | Not tested |
| $q''_{ig,\min}$ (correlation) | 36.60 | 39.26 | 62.01 | 62.01 | Not tested |
| $q''_s$ (correlation) | 11.30 | 11.30 | 9.61 | 9.61 | Not tested |
| $q''_s$ ( from extent of flame spread) | 12.41<br>*Std Dev 1.18* | 12.41<br>*Std Dev 1.18* | 11.57<br>*Std Dev1.38* | 11.57<br>*Std Dev 1.38* | Not tested |
| **Melteca faced MDF** | *RIFT (using ISO 5657 ignition data* | *RIFT (Using RIFT ign data* | *RIFT (Using RIFT ign data* | *RIFT (Using ISO 5657 ign data* | *LIFT* |
| | Low preheat time | Low preheat time | Full preheat time | Full preheat time | Full preheat time |
| Flame spread modulus *C* | 13.40 | 2.32 | 6.44 | 6.44 | 4.3 |
| Flame spread parameter $\Phi$ | 3.85 | 90.36 | 11.74 | 16.67 | 38.5 |
| $q''_{ig,\min}$ (ignition test) | 20.00 | 21.25 | 21.25 | 20.00 | 18.8 |
| $q''_{ig,\min}$ (correlation) | 20.00 | 46.10 | 30.74 | 30.74 | 33.0 |
| $q''_s$ (correlation) | 11.30 | 12.91 | 11.48 | 11.48 | 10.9 |
| $q''_s$ ( from extent of flame spread) | 14.16<br>*Std Dev 1.63* | 14.16<br>*Std Dev 1.63* | 13.96<br>*Std Dev 1.78* | 13.96<br>*Std Dev 1.78* | 9.9<br>*Std Dev 0.16* |

| **Pynefloor Particle board flooring** | *RIFT - with ISO 5657 ign data* | *RIFT - with RIFT ignition data* | *RIFT - with ISO 5657 ignition data* | *RIFT – with RIFT ignition data* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheating time | Low preheating time | Full preheating time | Full preheating time | Full preheating time |
| Flame spread modulus *C* | 19.5 | 9.3 | 8.1 | 8.1 | 3.6 |
| Flame spread parameter $\Phi$ | 2.8 | 3.7 | 14.8 | 4.9 | 37.3 |
| $q''_{ig,\min}$ (ignition test) | 0.0 | 0.0 | 18.8 | 21.3 | 0.0 |
| $q''_{ig,\min}$ (correlation) | 11.8 | 20.2 | 19.0 | 19.0 | 25.5 |
| $q''_{s}$ (correlation) | 6.6 | 8.4 | 7.5 | 7.5 | 6.2 |
| $q''_{s}$ ( from extent of flame spread) | 8.7 | 8.7 | 7.6 | 7.6 | 6.3 |
| | *Std Dev* 0.74 | *Std Dev* 0.74 | *Std Dev* 0.61 | *Std Dev* 0.61 | *Std Dev* 0.73 |

| **Superflake Particle board** | *RIFT - 20mm particle board with ISO 5657 ign data* | *RIFT - 20mm particle board with RIFT ignition data* | *RIFT - 20mm particle board with ISO 5657 ignition data* | *RIFT - with RIFT ignition data* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheating time | Low preheating time | Full preheating time | Full preheating time | Full preheating time |
| Flame spread modulus *C* | 24.77 | 13.79 | 7.58 | 7.58 | Not Tested |
| Flame spread parameter $\Phi$ | 1.94 | 2.61 | 20.71 | 8.62 | Not tested |
| $q''_{ig,\min}$ (ignition test) | 13.75 | 18.75 | 13.75 | 18.75 | Not tested |
| $q''_{ig,\min}$ (correlation) | 10.44 | 16.70 | 18.61 | 18.61 | Not tested |
| $q''_{s}$ (correlation) | 6.60 | 8.39 | 7.48 | 7.48 | Not tested |
| $q''_{s}$ ( from extent of flame spread) | 9.75 | 9.75 | 7.41 | 7.41 | Not tested |
| | *Std Dev* 1.58 | *Std Dev* 1.58 | *Std Dev* 0.71 | *Std Dev* 0.71 | |

| **Hardboard** | *RIFT (using ISO ignition data* | *RIFT (Using RIFT ign data* | *RIFT (using ISO ignition data* | *RIFT (Using RIFT ign data* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheat time | Low preheat time | Full preheat time | Full preheat time | Full preheat time |
| Flame spread modulus *C* | 13.3 | 13.6 | 5.7 | 5.7 | 4.9 |
| Flame spread parameter $\Phi$ | 6.7 | 6.7 | 36.8 | 38.1 | 20.3 |
| $q''_{ig,\min}$ (ignition test) | 11.3 | 11.3 | 11.3 | 11.3 | 17.5 |
| $q''_{ig,\min}$ (correlation) | 11.1 | 10.9 | 19.2 | 19.2 | 19.5 |
| $q''_s$ (correlation) | 3.3 | 3.3 | 3.3 | 3.3 | 3.1 |
| $q''_s$ ( from extent of flame spread) | 4.1 *Std Dev* 0.9 | 4.1 *Std Dev* 0.9 | 3.2 *Std Dev* 0.3 | 3.2 *Std Dev* 0.3 | 3.4 *Std Dev* 0.4 |

| **NZ Beech** | *RIFT (using ISO ignition data* | *RIFT (Using RIFT ign data* | *RIFT (using ISO ignition data* | *RIFT (Using RIFT ign data* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheat time | Low preheat time | Full preheat time | Full preheat time | Full preheat time |
| Flame spread modulus *C* | 4.7 | 7.3 | 2.5 | 2.5 | 2.7 |
| Flame spread parameter $\Phi$ | 20.2 | 20.2 | 74.8 | 177.7 | 70.9 |
| $q''_{ig,\min}$ (ignition test) | 18.0 | 18.75 | 18.00 | 18.75 | 18.75 |
| $q''_{ig,\min}$ (correlation) | 16.2 | 10.5 | 22.3 | 22.3 | 23.7 |
| $q''_s$ (correlation) | 6.5 | 4.2 | 2.9 | 2.9 | 3.7 |
| $q''_s$ ( from extent of flame spread) | 9.6 *Std Dev* 2.0 | 9.6 *Std Dev* 2.0 | 3.3 *Std Dev* 0.3 | 3.3 *Std Dev* 0.3 | 4.8 *Std Dev* 0.9 |

| **Radiata Pine** | *RIFT (using ISO ignition data* | *RIFT (Using RIFT ign data* | *RIFT (Using ISO 5657 ign data* | *RIFT (Using RIFT ign data)* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheat time | Low preheat time | Full preheat time | Full preheat time | Full preheat time |
| Flame spread modulus *C* | 12.3 | 11.1 | 5.0 | 5.0 | 4.0 |
| Flame spread parameter $\Phi$ | 5.4 | 5.4 | 32.6 | 26.9 | 27.4 |
| $q''_{ig,\min}$ (ignition test) | 16.25 | 18.75 | 16.25 | 18.75 | 18.75 |
| $q''_{ig,\min}$ (correlation) | 10.2 | 11.2 | 17.6 | 17.6 | 18.0 |
| $q''_s$ (correlation) | 4.9 | 5.3 | 3.8 | 3.8 | 4.2 |
| $q''_s$ ( from extent of flame spread) | 7.5 | 7.5 | 3.8 | 3.8 | 4.5 |
| | *Std Dev* 1.0 | *Std Dev* 1.0 | *Std Dev* 0.1 | *Std Dev* 0.1 | *Std Dev* 0.7 |

| **Rimu** | *RIFT (using ISO ignition data* | *RIFT (Using RIFT ign data* | *RIFT (using ISO ignition data* | *RIFT (Using RIFT ign data* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheat time | Low preheat time | Full preheat time | Full preheat time | Full preheat time |
| Flame spread modulus *C* | 4.7 | 5.1 | Insufficient flame spread | Insufficient flame spread | 2.2 |
| Flame spread parameter $\Phi$ | 22.5 | 22.5 | - | - | 106 |
| $q''_{ig,\min}$ (ignition test) | 18.0 | 21.25 | 18.0 | 21.25 | 18.5 |
| $q''_{ig,\min}$ (correlation) | 15.9 | 14.8 | Insufficient flame spread | Insufficient flame spread | 26.0 |
| $q''_s$ (correlation) | 5.4 | 5.0 | Insufficient flame spread | Insufficient flame spread | 6.0 |
| $q''_s$ ( from extent of flame spread) | 11.7 | 11.7 | | | 7.6 |
| | *Std Dev* 2.3 | *std Dev* 2.3 | 12.7 | 12.7 | *Std Dev* 2.7 |

| **Macrocarpa** | *RIFT (using ISO 5657 ignition data)* | *RIFT (Using RIFT ign data)* | *RIFT (Using ISO 5657 ign data)* | *RIFT (Using RIFT ign data* | *LIFT* |
|---|---|---|---|---|---|
| | Low preheating time | Low preheating time | Full preheat time | Full preheat time | Full preheating time |
| Flame spread modulus *C* | 7.7 | 6.9 | 2.9 | 2.9 | 2.5 |
| Flame spread parameter $\Phi$ | 9.3 | 8.6 | 64.5 | 48.0 | 58.3 |
| $q''_{ig,\min}$ (ignition test) | 18.0 | 18.8 | 18.0 | 18.8 | 18.8 |
| $q''_{ig,\min}$ (correlation) | 12.7 | 14.5 | 22.6 | 22.6 | 18.9 |
| $q''_{s}$ (correlation) | 4.1 | 4.6 | 4.6 | 4.6 | 2.2 |
| $\dot{q}''_{s}$ ( from extent of flame spread) | 6.1<br>*Std Dev* 1.0 | 6.1<br>*Std Dev* 1.0 | 5.0<br>*Std Dev* 0.8 | 5.0<br>*Std Dev* 0.8 | 2.2<br>*Std Dev* 0.2 |

## *12.2 Flame spread data and correlation results*

**Plywood, 17mm**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Plywood Test 1** | Ignition Time | 295 | | | | | | m/s | mm/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | | |
| 175 | 305 | 10 | | | | | | | | 1.000 | 19.66 | 19.66 | |
| 200 | 312 | 17 | 939 | 600 | 294053 | 881721 | 188225 | 0.0029 | 2.9110 | 1.000 | 19.05 | 19.05 | 18.535 |
| 225 | 322 | 27 | 967 | 675 | 311917 | 935089 | 218100 | 0.0024 | 2.3792 | 1.000 | 18.25 | 18.25 | 20.502 |
| 250 | 333 | 38 | 996 | 750 | 330854 | 992016 | 249475 | 0.0026 | 2.6099 | 1.000 | 17.45 | 17.45 | 19.574 |
| 275 | 341 | 46 | 1030 | 825 | 353906 | 1060900 | 283825 | 0.0021 | 2.1088 | 1.000 | 15.86 | 15.86 | 21.776 |
| 300 | 356 | 61 | 1073 | 900 | 384393 | 1151329 | 322775 | 0.0014 | 1.4189 | 1.000 | 14.28 | 14.28 | 26.547 |
| 325 | 376 | 81 | 1138 | 975 | 432948 | 1295044 | 371100 | 0.0010 | 0.9868 | 1.000 | 12.89 | 12.89 | 31.833 |
| 350 | 406 | 111 | 1218 | 1050 | 496308 | 1483524 | 427800 | 0.0008 | 0.8333 | 1.000 | 11.50 | 11.50 | 34.641 |
| 375 | 436 | 141 | 1323 | 1125 | 586293 | 1750329 | 498000 | 0.0007 | 0.6579 | 1.000 | 10.17 | 10.17 | 38.987 |
| 400 | 481 | 186 | 1454 | 1200 | 709826 | 2114116 | 584125 | 0.0005 | 0.4931 | 1.000 | 8.83 | 8.83 | 45.033 |
| 425 | 537 | 242 | 1630 | 1275 | 894274 | 2656900 | 696025 | 0.0004 | 0.3790 | 1.000 | 7.59 | 7.59 | 51.365 |
| 450 | 612 | 317 | 1862 | 1350 | 1171282 | 3467044 | 842300 | 0.0003 | 0.2820 | 1.000 | 6.35 | 6.35 | 59.545 |
| 475 | 713 | 418 | | | | | | | | 1.000 | 5.42 | 5.42 | |
| 500 | 870 | 575 | | | | | | | | | | | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Plywood Test 2** | Ignition Time | 307 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ | (m/s)$^{-0.5}$ |
| 50 | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | | |
| 225 | 319 | 24 | | | | | | | | 1.000 | 18.25 | 18.25 | |
| 250 | 328 | 33 | 987 | 750 | 324945 | 974169 | 247275 | 0.0024 | 2.3649 | 1.000 | 17.45 | 17.45 | 20.563 |
| 275 | 340 | 45 | 1021 | 825 | 347793 | 1042441 | 281400 | 0.0020 | 1.9989 | 1.000 | 15.86 | 15.86 | 22.367 |
| 300 | 353 | 58 | 1060 | 900 | 374898 | 1123600 | 318675 | 0.0019 | 1.8510 | 1.000 | 14.28 | 14.28 | 23.243 |
| 325 | 367 | 72 | 1108 | 975 | 409842 | 1227664 | 360975 | 0.0014 | 1.4098 | 1.000 | 12.89 | 12.89 | 26.633 |
| 350 | 388 | 93 | 1169 | 1050 | 456629 | 1366561 | 410325 | 0.0011 | 1.0598 | 1.000 | 11.50 | 11.50 | 30.717 |
| 375 | 414 | 119 | 1245 | 1125 | 518189 | 1550025 | 468250 | 0.0009 | 0.9082 | 1.000 | 10.17 | 10.17 | 33.183 |
| 400 | 443 | 148 | 1338 | 1200 | 599006 | 1790244 | 536875 | 0.0007 | 0.7418 | 1.000 | 8.83 | 8.83 | 36.716 |
| 425 | 481 | 186 | 1470 | 1275 | 725726 | 2160900 | 627325 | 0.0005 | 0.4746 | 1.000 | 7.59 | 7.59 | 45.904 |
| 450 | 546 | 251 | 1678 | 1350 | 953278 | 2815684 | 759350 | 0.0003 | 0.2888 | 1.000 | 6.35 | 6.35 | 58.845 |
| 475 | 651 | 356 | 1945 | 1424 | 1281421 | 3783025 | 928177 | 0.0002 | 0.2425 | 1.000 | 5.42 | 5.42 | 64.214 |
| 499 | 748 | 453 | | | | | | | | 1.000 | 4.53 | 4.53 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Plywood Test 3** | Ignition Time | 295 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ | (m/s)$^{-0.5}$ |
| 50 | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | | |
| 225 | 307 | 12 | | | | | | | | 1.000 | 18.25 | 18.25 | |
| 250 | 314 | 19 | 943 | 750 | 296529 | 889249 | 236125 | 0.0033 | 3.3284 | 1.000 | 17.45 | 17.45 | 17.333 |
| 275 | 322 | 27 | 969 | 825 | 313169 | 938961 | 266950 | 0.0026 | 2.6099 | 1.000 | 15.86 | 15.86 | 19.574 |
| 300 | 333 | 38 | 1001 | 900 | 334289 | 1002001 | 300900 | 0.0021 | 2.0785 | 1.000 | 14.28 | 14.28 | 21.934 |
| 325 | 346 | 51 | 1041 | 975 | 361649 | 1083681 | 339050 | 0.0017 | 1.7180 | 1.000 | 12.89 | 12.89 | 24.126 |
| 350 | 362 | 67 | 1091 | 1050 | 397449 | 1190281 | 382775 | 0.0013 | 1.3432 | 1.000 | 11.50 | 11.50 | 27.286 |
| 375 | 383 | 88 | 1160 | 1125 | 449958 | 1345600 | 436325 | 0.0009 | 0.9300 | 1.000 | 10.17 | 10.17 | 32.791 |
| 400 | 415 | 120 | 1255 | 1200 | 527763 | 1575025 | 503850 | 0.0007 | 0.6716 | 1.000 | 8.83 | 8.83 | 38.588 |
| 425 | 457 | 162 | 1424 | 1275 | 685778 | 2027776 | 608625 | 0.0003 | 0.3476 | 1.000 | 7.59 | 7.59 | 53.635 |
| 450 | 552 | 257 | 1772 | 1340 | 1095722 | 3139984 | 797420 | 0.0001 | 0.1208 | 1.000 | 6.35 | 6.35 | 90.983 |
| 465 | 763 | 468 | | | | | | | | 1.000 | 5.79 | 5.79 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 9mm plywood low preheat time Test 1** | Ignition Time | 66 | | | | | | m/s | | kW/m² | |
| 10 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 40 | | | | | | | | | | | |
| 50 | 66 | 0 | | | | | | | 0.320 | 27.20 | |
| 60 | 78 | 12 | 227 | 180 | 17329 | 51529 | 13790 | 0.0011 | 0.348 | 24.94 | 8.68 |
| 70 | 83 | 17 | 254 | 210 | 21622 | 64516 | 17930 | 0.0013 | 0.359 | 22.89 | 8.22 |
| 80 | 93 | 27 | 279 | 240 | 26147 | 77841 | 22520 | 0.0010 | 0.380 | 20.84 | 7.92 |
| 90 | 103 | 37 | 309 | 270 | 32027 | 95481 | 28010 | 0.0010 | 0.400 | 18.76 | 7.50 |
| 100 | 113 | 47 | 346 | 300 | 40278 | 119716 | 34870 | 0.0007 | 0.419 | 16.68 | 6.99 |
| 110 | 130 | 64 | 399 | 330 | 54005 | 159201 | 44320 | 0.0005 | 0.449 | 15.08 | 6.77 |
| 120 | 156 | 90 | 483 | 360 | 80045 | 233289 | 58630 | 0.0003 | 0.492 | 13.96 | 6.87 |
| 130 | 197 | 131 | 591 | 390 | 119789 | 349281 | 77650 | 0.0002 | 0.553 | 12.83 | 7.10 |
| 140 | 238 | 172 | 699 | 420 | 165149 | 488601 | 98530 | 0.0003 | 0.608 | 11.74 | 7.14 |
| 150 | 264 | 198 | 785 | 450 | 206429 | 616225 | 118200 | 0.0004 | 0.640 | 10.65 | 6.81 |
| 160 | 283 | 217 | 899 | 480 | 273689 | 808201 | 144720 | 0.0002 | 0.663 | 9.56 | 6.33 |
| 170 | 352 | 286 | 1357 | 510 | 725277 | 1841449 | 235080 | 0.0000 | 0.739 | 8.47 | 6.26 |
| 180 | 722 | 656 | | | | | | | 1.000 | 7.39 | 7.39 |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 9mm plywood low preheat time Test 2** | Ignition Time | 81s | | | | | | m/s | | kW/m² | |
| 10 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 40 | 81 | 0 | | | | | | | 0.355 | 29.67 | |
| 50 | 85 | 4 | 257 | 150 | 22067 | 66049 | 12950 | 0.0020 | 0.363 | 27.20 | 9.88 |
| 60 | 91 | 10 | 271 | 180 | 24531 | 73441 | 16360 | 0.0020 | 0.376 | 24.94 | 9.37 |
| 70 | 95 | 14 | 285 | 210 | 27107 | 81225 | 20030 | 0.0025 | 0.384 | 22.89 | 8.79 |
| 80 | 99 | 18 | 299 | 240 | 29851 | 89401 | 24020 | 0.0020 | 0.392 | 20.84 | 8.17 |
| 90 | 105 | 24 | 318 | 270 | 33822 | 101124 | 28770 | 0.0013 | 0.404 | 18.76 | 7.57 |
| 100 | 114 | 33 | 346 | 300 | 40150 | 119716 | 34820 | 0.0009 | 0.421 | 16.68 | 7.02 |
| 110 | 127 | 46 | 386 | 330 | 50150 | 148996 | 42770 | 0.0006 | 0.444 | 15.08 | 6.70 |
| 120 | 145 | 64 | 441 | 360 | 65715 | 194481 | 53340 | 0.0005 | 0.474 | 13.96 | 6.62 |
| 130 | 169 | 88 | 512 | 390 | 88790 | 262144 | 67090 | 0.0004 | 0.512 | 12.83 | 6.57 |
| 140 | 198 | 117 | 589 | 420 | 117049 | 346921 | 82990 | 0.0004 | 0.554 | 11.74 | 6.51 |
| 150 | 222 | 141 | 671 | 450 | 151489 | 450241 | 101180 | 0.0004 | 0.587 | 10.65 | 6.25 |
| 160 | 251 | 170 | | | | | | | 0.624 | 9.56 | 5.97 |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 9mm plywood low preheat time Test 3** | Ignition Time | 69s | | | | | | m/s | | kW/m² | |
| 10 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |
| 60 | 69 | 0 | | | | | | | 0.327 | 24.94 | |
| 70 | 72 | 3 | 216 | 210 | 15570 | 46656 | 15180 | 0.0033 | 0.334 | 22.89 | 7.65 |
| 80 | 75 | 6 | 229 | 240 | 17533 | 52441 | 18420 | 0.0019 | 0.341 | 20.84 | 7.11 |
| 90 | 82 | 13 | 252 | 270 | 21374 | 63504 | 22880 | 0.0010 | 0.357 | 18.76 | 6.69 |
| 100 | 95 | 26 | 287 | 300 | 27849 | 82369 | 28980 | 0.0007 | 0.384 | 16.68 | 6.41 |
| 110 | 110 | 41 | 339 | 330 | 39081 | 114921 | 37680 | 0.0005 | 0.413 | 15.08 | 6.23 |
| 120 | 134 | 65 | 400 | 360 | 54392 | 160000 | 48460 | 0.0004 | 0.456 | 13.96 | 6.37 |
| 130 | 156 | 87 | 471 | 390 | 75053 | 221841 | 61700 | 0.0004 | 0.492 | 12.83 | 6.31 |
| 140 | 181 | 112 | 540 | 420 | 98306 | 291600 | 76070 | 0.0004 | 0.530 | 11.74 | 6.22 |
| 150 | 203 | 134 | 603 | 450 | 121931 | 363609 | 90830 | 0.0005 | 0.561 | 10.65 | 5.98 |
| 160 | 219 | 150 | 666 | 480 | 148706 | 443556 | 106970 | 0.0005 | 0.583 | 9.56 | 5.57 |
| 170 | 244 | 175 | 742 | 510 | 185338 | 550564 | 126740 | 0.0003 | 0.615 | 8.47 | 5.21 |
| 180 | 279 | 210 | 842 | 535 | 239138 | 708964 | 150715 | 0.0002 | 0.658 | 7.39 | 4.86 |
| 185 | 319 | 250 | | | | | | | 0.704 | 7.02 | 4.94 |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 9mm plywood low preheat time Test 4** | Ignition Time | 66s | | | | | | m/s | | kW/m² | |
| 10 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | 66 | 0 | | | | | | | | | |
| 40 | 75 | 9 | 218 | 120 | 15910 | 47524 | 8830 | 0.0016 | 0.341 | 29.67 | 10.12 |
| 50 | 77 | 11 | 231 | 150 | 17795 | 53361 | 11590 | 0.0050 | 0.346 | 27.20 | 9.40 |
| 60 | 79 | 13 | 239 | 180 | 19059 | 57121 | 14400 | 0.0032 | 0.350 | 24.94 | 8.73 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 83 | 17 | 248 | 210 | 20526 | 61504 | 17430 | 0.0028 | 0.359 | 22.89 | 8.22 |
| 80 | 86 | 20 | 262 | 240 | 22934 | 68644 | 21060 | 0.0019 | 0.365 | 20.84 | 7.61 |
| 90 | 93 | 27 | 280 | 270 | 26246 | 78400 | 25350 | 0.0013 | 0.380 | 18.76 | 7.13 |
| 100 | 101 | 35 | 305 | 300 | 31171 | 93025 | 30680 | 0.0011 | 0.396 | 16.68 | 6.60 |
| 110 | 111 | 45 | 338 | 330 | 38398 | 114244 | 37430 | 0.0008 | 0.415 | 15.08 | 6.26 |
| 120 | 126 | 60 | 393 | 360 | 52533 | 154449 | 47610 | 0.0004 | 0.442 | 13.96 | 6.17 |
| 130 | 156 | 90 | 452 | 390 | 69112 | 204304 | 59200 | 0.0004 | 0.492 | 12.83 | 6.31 |
| 140 | 170 | 104 | 512 | 420 | 87832 | 262144 | 71980 | 0.0007 | 0.514 | 11.74 | 6.03 |
| 150 | 186 | 120 | 563 | 450 | 106345 | 316969 | 84820 | 0.0005 | 0.537 | 10.65 | 5.72 |
| 160 | 207 | 141 | 683 | 480 | 161545 | 466489 | 110320 | 0.0002 | 0.567 | 9.56 | 5.42 |
| 170 | 290 | 224 | 841 | 510 | 245285 | 707281 | 144340 | 0.0001 | 0.671 | 8.47 | 5.68 |
| 180 | 344 | 278 | 1019 | 533 | 350661 | ###### | 181675 | 0.0001 | 0.731 | 7.39 | 5.40 |
| 183 | 385 | 319 | | | | | | | 0.773 | 7.17 | 5.54 |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 9mm plywood low preheat time Test 5** | Ignition Time | 67s | | | | | | m/s | | kW/m² | |
| 10 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 40 | | | | | | | | | | | |
| 50 | 67 | 0 | 140 | 150 | 9818 | 19600 | 7730 | 0.0002 | 0.323 | 27.20 | 8.77 |
| 60 | 73 | 6 | 221 | 180 | 16379 | 48841 | 13400 | 0.0014 | 0.337 | 24.94 | 8.39 |
| 70 | 81 | 14 | 245 | 210 | 20171 | 60025 | 17330 | 0.0011 | 0.355 | 22.89 | 8.12 |
| 80 | 91 | 24 | 276 | 240 | 25658 | 76176 | 22310 | 0.0009 | 0.376 | 20.84 | 7.83 |
| 90 | 104 | 37 | 313 | 270 | 33021 | 97969 | 28440 | 0.0007 | 0.402 | 18.76 | 7.54 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 118 | 51 | 359 | 300 | 43509 | 128881 | 36230 | 0.0006 | 0.428 | 16.68 | 7.14 |
| 110 | 137 | 70 | 417 | 330 | 58937 | 173889 | 46310 | 0.0005 | 0.461 | 15.08 | 6.95 |
| 120 | 162 | 95 | 482 | 360 | 78502 | 232324 | 58300 | 0.0004 | 0.501 | 13.96 | 7.00 |
| 130 | 183 | 116 | 556 | 390 | 104254 | 309136 | 72770 | 0.0004 | 0.533 | 12.83 | 6.84 |
| 140 | 211 | 144 | 634 | 420 | 135610 | 401956 | 89330 | 0.0004 | 0.572 | 11.74 | 6.72 |
| 150 | 240 | 173 | 723 | 450 | 176105 | 522729 | 109060 | 0.0003 | 0.610 | 10.65 | 6.50 |
| 160 | 272 | 205 | 825 | 480 | 229553 | 680625 | 132730 | 0.0003 | 0.650 | 9.56 | 6.21 |
| 170 | 313 | 246 | 951 | 510 | 305909 | 904401 | 162610 | 0.0002 | 0.697 | 8.47 | 5.91 |
| 180 | 366 | 299 | 1102 | 540 | 410854 | 1214404 | 199460 | 0.0002 | 0.754 | 7.39 | 5.57 |
| 190 | 423 | 356 | 1257 | 570 | 531909 | 1580049 | 239850 | 0.0002 | 0.810 | 6.66 | 5.40 |
| 200 | 468 | 401 | 1423 | 600 | 680977 | 2024929 | 285690 | 0.0002 | 0.852 | 5.93 | 5.06 |
| 210 | 532 | 465 | 1600 | 630 | 862048 | 2560000 | 337320 | 0.0002 | 0.909 | 5.25 | 4.77 |
| 220 | 600 | 533 | 1805 | 660 | 1095953 | 3258025 | 398510 | 0.0001 | 0.965 | 4.62 | 4.46 |
| 230 | 673 | 606 | 2003 | 690 | 1345829 | 4012009 | 461990 | 0.0002 | 1.022 | 3.99 | 4.08 |
| 240 | 730 | 663 | 2246 | 715 | 1696478 | 5044516 | 536525 | 0.0001 | 1.000 | 3.74 | 3.74 |
| 245 | 843 | 776 | | | | | | | 1.000 | 3.62 | 3.62 |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 9mm plywood low preheat time Test** 6 | Ignition Time | 66s | | | | | | m/s | | kW/m² | |
| 10 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 40 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |
| 60 | 67 | 0 | | | | | | 0.0002 | 0.323 | 24.94 | |
| 70 | 78 | 11 | 239 | 210 | 19409 | 57121 | 17000 | 0.0007 | 0.348 | 22.89 | 7.96 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 94 | 27 | 281 | 240 | 26801 | 78961 | 22790 | 0.0006 | 0.382 | 20.84 | 7.96 |
| 90 | 109 | 42 | 330 | 270 | 36846 | 108900 | 30030 | 0.0006 | 0.411 | 18.76 | 7.72 |
| 100 | 127 | 60 | 381 | 300 | 49035 | 145161 | 38460 | 0.0006 | 0.444 | 16.68 | 7.41 |
| 110 | 145 | 78 | 435 | 330 | 63723 | 189225 | 48210 | 0.0006 | 0.474 | 15.08 | 7.15 |
| 120 | 163 | 96 | 503 | 360 | 85619 | 253009 | 60860 | 0.0004 | 0.503 | 13.96 | 7.02 |
| 130 | 195 | 128 | 586 | 390 | 116578 | 343396 | 76830 | 0.0003 | 0.550 | 12.83 | 7.06 |
| 140 | 228 | 161 | 713 | 419 | 174109 | 508369 | 100480 | 0.0002 | 0.595 | 11.74 | 6.98 |
| 149 | 290 | 223 | | | | | | | 0.671 | 10.75 | 7.22 |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood low preheat time Test 1** | Ignition Time | 69 | | | | | | m/s | | kW/m² | |
| 10 | 69 | 0 | | | | | | | | 37.09 | |
| 20 | 69.5 | 0.5 | 208 | 60 | 14422 | 43264 | 4165 | 0.0300 | 0.401 | 34.62 | 13.89 |
| 30 | 69.5 | 0.5 | 209 | 90 | 14561 | 43681 | 6275 | 0.0300 | 0.401 | 32.14 | 12.89 |
| 40 | 70 | 1 | 213 | 120 | 15059 | 45156 | 8535 | 0.0049 | 0.403 | 29.67 | 11.94 |
| 50 | 73 | 4 | 219 | 150 | 16005 | 47961 | 11010 | 0.0033 | 0.411 | 27.20 | 11.18 |
| 60 | 76 | 7 | 234 | 180 | 18330 | 54756 | 14160 | 0.0015 | 0.419 | 24.94 | 10.46 |
| 70 | 85 | 16 | 253 | 210 | 21465 | 64009 | 17870 | 0.0012 | 0.444 | 22.89 | 10.15 |
| 80 | 92 | 23 | 280 | 240 | 26298 | 78400 | 22580 | 0.0011 | 0.461 | 20.84 | 9.62 |
| 90 | 103 | 34 | 310 | 270 | 32298 | 96100 | 28130 | 0.0009 | 0.488 | 18.76 | 9.16 |
| 100 | 115 | 46 | 350 | 300 | 41258 | 122500 | 35290 | 0.0007 | 0.516 | 16.68 | 8.61 |
| 110 | 132 | 63 | 397 | 330 | 53149 | 157609 | 44020 | 0.0006 | 0.553 | 15.08 | 8.34 |
| 120 | 150 | 81 | 454 | 360 | 69508 | 206116 | 54880 | 0.0005 | 0.589 | 13.96 | 8.22 |
| 130 | 172 | 103 | 520 | 390 | 91288 | 270400 | 68080 | 0.0004 | 0.631 | 12.83 | 8.10 |
| 140 | 198 | 129 | 600 | 420 | 121688 | 360000 | 84580 | 0.0003 | 0.677 | 11.74 | 7.95 |
| 150 | 230 | 161 | 704 | 450 | 168280 | 495616 | 106380 | 0.0003 | 0.730 | 10.65 | 7.77 |
| 160 | 276 | 207 | 815 | 480 | 224557 | 664225 | 131190 | 0.0003 | 0.799 | 9.56 | 7.64 |
| 170 | 309 | 240 | 946 | 510 | 301978 | 894916 | 161670 | 0.0002 | 0.846 | 8.47 | 7.17 |
| 180 | 361 | 292 | 1082 | 540 | 395546 | 1170724 | 195790 | 0.0002 | 0.914 | 7.39 | 6.75 |
| 190 | 412 | 343 | 1194 | 570 | 477306 | 1425636 | 227460 | 0.0003 | 0.977 | 6.66 | 6.50 |
| 200 | 421 | 352 | 1401 | 598 | 669609 | 1962801 | 280624 | 0.0001 | 0.987 | 5.93 | 5.85 |
| 208 | 568 | 499 | | | | | | | | 5.39 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood low preheat time Test 2** | Ignition Time | 50 | | | | | | m/s | | kW/m² | |
| 10 | 50 | 0 | | | | | | | 0.340 | 37.09 | |
| 20 | 52 | 2 | 155 | 60 | 8013 | 24025 | 3130 | 0.0064 | 0.347 | 34.62 | 12.01 |
| 30 | 53 | 3 | 159 | 90 | 8429 | 25281 | 4790 | 0.0100 | 0.350 | 32.14 | 11.26 |
| 40 | 54 | 4 | 162 | 120 | 8750 | 26244 | 6500 | 0.0100 | 0.354 | 29.67 | 10.49 |
| 50 | 55 | 5 | 169 | 150 | 9541 | 28561 | 8510 | 0.0029 | 0.357 | 27.20 | 9.70 |
| 60 | 60 | 10 | 181 | 180 | 10981 | 32761 | 10970 | 0.0018 | 0.373 | 24.94 | 9.29 |
| 70 | 66 | 16 | 201 | 210 | 13581 | 40401 | 14220 | 0.0013 | 0.391 | 22.89 | 8.95 |
| 80 | 75 | 25 | 229 | 240 | 17725 | 52441 | 18540 | 0.0009 | 0.417 | 20.84 | 8.68 |
| 90 | 88 | 38 | 264 | 270 | 23570 | 69696 | 24020 | 0.0008 | 0.451 | 18.76 | 8.47 |
| 100 | 101 | 51 | 305 | 300 | 31401 | 93025 | 30780 | 0.0007 | 0.484 | 16.68 | 8.06 |
| 110 | 116 | 66 | 349 | 330 | 41081 | 121801 | 38700 | 0.0006 | 0.518 | 15.08 | 7.81 |
| 120 | 132 | 82 | 400 | 360 | 53984 | 160000 | 48360 | 0.0006 | 0.553 | 13.96 | 7.71 |
| 130 | 152 | 102 | 461 | 390 | 71857 | 212521 | 60380 | 0.0004 | 0.593 | 12.83 | 7.61 |
| 140 | 177 | 127 | 536 | 420 | 97282 | 287296 | 75590 | 0.0004 | 0.640 | 11.74 | 7.51 |
| 150 | 207 | 157 | 626 | 450 | 132742 | 391876 | 94550 | 0.0003 | 0.692 | 10.65 | 7.37 |
| 160 | 242 | 192 | 732 | 480 | 181502 | 535824 | 117880 | 0.0003 | 0.748 | 9.56 | 7.15 |
| 170 | 283 | 233 | | | | | | | 0.809 | 8.47 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood low preheat time Test 3** | Ignition Time | 69 | | | | | | m/s | | kW/m² | |
| 10 | 50 | 0 | | | | | | | 0.340 | 37.09 | |
| 20 | 52 | 2 | 155 | 60 | 8013 | 24025 | 3130 | 0.0064 | 0.347 | 34.62 | 12.01 |
| 30 | 53 | 3 | 159 | 90 | 8429 | 25281 | 4790 | 0.0100 | 0.350 | 32.14 | 11.26 |
| 40 | 54 | 4 | 162 | 120 | 8750 | 26244 | 6500 | 0.0100 | 0.354 | 29.67 | 10.49 |
| 50 | 55 | 5 | 169 | 150 | 9541 | 28561 | 8510 | 0.0029 | 0.357 | 27.20 | 9.70 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 60 | 10 | 181 | 180 | 10981 | 32761 | 10970 | 0.0018 | 0.373 | 24.94 | 9.29 |
| 70 | 66 | 16 | 201 | 210 | 13581 | 40401 | 14220 | 0.0013 | 0.391 | 22.89 | 8.95 |
| 80 | 75 | 25 | 229 | 240 | 17725 | 52441 | 18540 | 0.0009 | 0.417 | 20.84 | 8.68 |
| 90 | 88 | 38 | 264 | 270 | 23570 | 69696 | 24020 | 0.0008 | 0.451 | 18.76 | 8.47 |
| 100 | 101 | 51 | 305 | 300 | 31401 | 93025 | 30780 | 0.0007 | 0.484 | 16.68 | 8.06 |
| 110 | 116 | 66 | 349 | 330 | 41081 | 121801 | 38700 | 0.0006 | 0.518 | 15.08 | 7.81 |
| 120 | 132 | 82 | 400 | 360 | 53984 | 160000 | 48360 | 0.0006 | 0.553 | 13.96 | 7.71 |
| 130 | 152 | 102 | 461 | 390 | 71857 | 212521 | 60380 | 0.0004 | 0.593 | 12.83 | 7.61 |
| 140 | 177 | 127 | 536 | 420 | 97282 | 287296 | 75590 | 0.0004 | 0.640 | 11.74 | 7.51 |
| 150 | 207 | 157 | 626 | 450 | 132742 | 391876 | 94550 | 0.0003 | 0.692 | 10.65 | 7.37 |
| 160 | 242 | 192 | 732 | 480 | 181502 | 535824 | 117880 | 0.0003 | 0.748 | 9.56 | 7.15 |
| 170 | 283 | 233 | 859 | 510 | 250209 | 737881 | 146950 | 0.0002 | 0.809 | 8.47 | 6.86 |
| 180 | 334 | 284 | 999 | 539 | 337569 | 998001 | 180428 | 0.0002 | 0.879 | 7.39 | 6.50 |
| 189 | 382 | 332 | | | | | | | 0.940 | 6.73 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood low preheat time Test 4** | Ignition Time 69 | | | | | | | m/s | | kW/m² | |
| 10 | 50 | 0 | | | | | | | 0.340 | 37.09 | |
| 20 | 52 | 2 | 156 | 60 | 8120 | 24336 | 3160 | 0.0050 | 0.347 | 34.62 | 12.01 |
| 30 | 54 | 4 | 164 | 90 | 8984 | 26896 | 4980 | 0.0032 | 0.354 | 32.14 | 11.36 |
| 40 | 58 | 8 | 173 | 120 | 10001 | 29929 | 6990 | 0.0028 | 0.366 | 29.67 | 10.87 |
| 50 | 61 | 11 | 186 | 150 | 11574 | 34596 | 9390 | 0.0021 | 0.376 | 27.20 | 10.22 |
| 60 | 67 | 17 | 204 | 180 | 13986 | 41616 | 12390 | 0.0013 | 0.394 | 24.94 | 9.82 |
| 70 | 76 | 26 | 229 | 210 | 17661 | 52441 | 16220 | 0.0011 | 0.419 | 22.89 | 9.60 |
| 80 | 86 | 36 | 259 | 240 | 22581 | 67081 | 20930 | 0.0010 | 0.446 | 20.84 | 9.30 |
| 90 | 97 | 47 | 297 | 270 | 29801 | 88209 | 27010 | 0.0007 | 0.474 | 18.76 | 8.89 |
| 100 | 114 | 64 | 343 | 300 | 39829 | 117649 | 34650 | 0.0006 | 0.514 | 16.68 | 8.57 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 110 | 132 | 82 | 395 | 330 | 52621 | 156025 | 43800 | 0.0006 | 0.553 | 15.08 | 8.34 |
| 120 | 149 | 99 | 456 | 360 | 70250 | 207936 | 55150 | 0.0005 | 0.587 | 13.96 | 8.20 |
| 130 | 175 | 125 | 531 | 390 | 95675 | 281961 | 69610 | 0.0003 | 0.636 | 12.83 | 8.17 |
| 140 | 207 | 157 | 615 | 420 | 127763 | 378225 | 86680 | 0.0003 | 0.692 | 11.74 | 8.13 |
| 150 | 233 | 183 | 708 | 450 | 168962 | 501264 | 106810 | 0.0003 | 0.734 | 10.65 | 7.82 |
| 160 | 268 | 218 | 807 | 480 | 219749 | 651249 | 129850 | 0.0003 | 0.788 | 9.56 | 7.53 |
| 170 | 306 | 256 | 901 | 510 | 272389 | 811801 | 153760 | 0.0003 | 0.842 | 8.47 | 7.13 |
| 180 | 327 | 277 | | | | | | | 0.870 | 7.39 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood low preheat time Test 5** | Ignition Time | 69 | | | | | | m/s | | kW/m² | |
| 10 | 50 | 0 | | | | | | | 0.340 | 37.09 | |
| 20 | 52.5 | 2.5 | 158 | 60 | 8281 | 24806 | 3200 | 0.0040 | 0.349 | 34.62 | 12.07 |
| 30 | 55 | 5 | 168 | 90 | 9381 | 28056 | 5100 | 0.0026 | 0.357 | 32.14 | 11.47 |
| 40 | 60 | 10 | 184 | 120 | 11386 | 33856 | 7500 | 0.0014 | 0.373 | 29.67 | 11.06 |
| 50 | 69 | 19 | 205 | 150 | 14137 | 42025 | 10410 | 0.0012 | 0.400 | 27.20 | 10.87 |
| 60 | 76 | 26 | 227 | 180 | 17261 | 51529 | 13750 | 0.0015 | 0.419 | 24.94 | 10.46 |
| 70 | 82 | 32 | 247 | 210 | 20421 | 61009 | 17420 | 0.0015 | 0.436 | 22.89 | 9.97 |
| 80 | 89 | 39 | 271 | 240 | 24645 | 73441 | 21860 | 0.0011 | 0.454 | 20.84 | 9.46 |
| 90 | 100 | 50 | 304 | 270 | 31146 | 92416 | 27620 | 0.0008 | 0.481 | 18.76 | 9.03 |
| 100 | 115 | 65 | 352 | 300 | 41994 | 123904 | 35570 | 0.0005 | 0.516 | 16.68 | 8.61 |
| 110 | 137 | 87 | 406 | 330 | 55710 | 164836 | 45050 | 0.0005 | 0.563 | 15.08 | 8.49 |
| 120 | 154 | 104 | 469 | 360 | 74169 | 219961 | 56690 | 0.0005 | 0.597 | 13.96 | 8.33 |
| 130 | 178 | 128 | 545 | 390 | 100769 | 297025 | 71440 | 0.0003 | 0.642 | 12.83 | 8.24 |
| 140 | 213 | 163 | 638 | 420 | 138062 | 407044 | 90010 | 0.0003 | 0.702 | 11.74 | 8.24 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 247 | 197 | 750 | 450 | 190478 | 562500 | 113270 | 0.0003 | 0.756 | 10.65 | 8.05 |
| 160 | 290 | 240 | 880 | 480 | 262758 | 774400 | 141760 | 0.0002 | 0.819 | 9.56 | 7.83 |
| 170 | 343 | 293 | 1027 | 510 | 356985 | 1054729 | 175630 | 0.0002 | 0.891 | 8.47 | 7.55 |
| 180 | 394 | 344 | 1188 | 540 | 476286 | 1411344 | 214920 | 0.0002 | 0.955 | 7.39 | 7.06 |
| 190 | 451 | 401 | 1357 | 570 | 620781 | 1841449 | 259010 | 0.0002 | 1.000 | 6.66 | 6.66 |
| 200 | 512 | 462 | | | | | | | 1.000 | 5.93 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e . F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood low preheat time Test 6** | Ignition Time | 69 | | | | | | m/s | | kW/m² | |
| 10 | 51 | 0 | | | | | | | 0.344 | 37.09 | |
| 20 | 52 | 1 | 158 | 60 | 8330 | 24964 | 3200 | 0.0046 | 0.347 | 34.62 | 12.01 |
| 30 | 55 | 4 | 167 | 90 | 9329 | 27889 | 5090 | 0.0024 | 0.357 | 32.14 | 11.47 |
| 40 | 60 | 9 | 182 | 120 | 11114 | 33124 | 7400 | 0.0017 | 0.373 | 29.67 | 11.06 |
| 50 | 67 | 16 | 204 | 150 | 14018 | 41616 | 10370 | 0.0012 | 0.394 | 27.20 | 10.71 |
| 60 | 77 | 26 | 234 | 180 | 18518 | 54756 | 14270 | 0.0009 | 0.422 | 24.94 | 10.53 |
| 70 | 90 | 39 | 267 | 210 | 24029 | 71289 | 18920 | 0.0009 | 0.456 | 22.89 | 10.45 |
| 80 | 100 | 49 | 305 | 240 | 31325 | 93025 | 24650 | 0.0008 | 0.481 | 20.84 | 10.03 |
| 90 | 115 | 64 | 345 | 270 | 40125 | 119025 | 31350 | 0.0007 | 0.516 | 18.76 | 9.68 |
| 100 | 130 | 79 | 397 | 300 | 53229 | 157609 | 40070 | 0.0005 | 0.549 | 16.68 | 9.15 |
| 110 | 152 | 101 | 455 | 330 | 69933 | 207025 | 50480 | 0.0005 | 0.593 | 15.08 | 8.94 |
| 120 | 173 | 122 | 531 | 360 | 95469 | 281961 | 64260 | 0.0004 | 0.633 | 13.96 | 8.83 |
| 130 | 206 | 155 | 615 | 390 | 128061 | 378225 | 80580 | 0.0003 | 0.691 | 12.83 | 8.86 |
| 140 | 236 | 185 | 715 | 420 | 172661 | 511225 | 100770 | 0.0003 | 0.739 | 11.74 | 8.68 |
| 150 | 273 | 222 | 818 | 450 | 225706 | 669124 | 123430 | 0.0003 | 0.795 | 10.65 | 8.46 |
| 160 | 309 | 258 | 934 | 480 | 293914 | 872356 | 150230 | 0.0003 | 0.846 | 9.56 | 8.08 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 170 | | 352 | 301 | 1065 | 510 | 382601 | 1134225 | 182000 | 0.0002 | 0.903 | 8.47 | 7.65 |
| 180 | | 404 | 353 | 1216 | 540 | 498720 | 1478656 | 219960 | 0.0002 | 0.967 | 7.39 | 7.15 |
| 190 | | 460 | 409 | 1378 | 570 | 639012 | 1898884 | 262920 | 0.0002 | 1.000 | 6.66 | 6.66 |
| 200 | | 514 | 463 | 1550 | 600 | 807572 | 2402500 | 311160 | 0.0002 | 1.000 | 5.93 | 5.93 |
| 210 | | 576 | 525 | 1710 | 625 | 980372 | 2924100 | 357060 | 0.0001 | 1.000 | 5.25 | 5.25 |
| 215 | | 620 | 569 | | | | | | | 1.000 | 4.94 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood full preheat time Test 1** | Ignition Time 291 | | | | | | | m/s | | kW/m² | |
| 10 | 0 | 0 | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | | | |
| 80 | 0 | 0 | | | | | | | | | |
| 90 | 296 | 5 | | | | | | | | 18.76 | |
| 100 | 301 | 10 | 906 | 300 | 273698 | 820836 | 90730 | 0.0015 | 1.000 | 16.68 | 16.68 |
| 110 | 309 | 18 | 932 | 330 | 289766 | 868624 | 102730 | 0.0009 | 1.000 | 15.08 | 15.08 |
| 120 | 322 | 31 | 964 | 360 | 310054 | 929296 | 115920 | 0.0008 | 1.000 | 13.96 | 13.96 |
| 130 | 333 | 42 | 1000 | 390 | 333598 | 1000000 | 130230 | 0.0009 | 1.000 | 12.83 | 12.83 |
| 140 | 345 | 54 | 1071 | 420 | 384363 | 1147041 | 150540 | 0.0003 | 1.000 | 11.74 | 11.74 |
| 150 | 393 | 102 | 1155 | 450 | 447363 | 1334025 | 173970 | 0.0003 | 1.000 | 10.65 | 10.65 |
| 160 | 417 | 126 | 1249 | 480 | 521059 | 1560001 | 200300 | 0.0004 | 1.000 | 9.56 | 9.56 |
| 170 | 439 | 148 | 1323 | 510 | 584699 | 1750329 | 225410 | 0.0004 | 1.000 | 8.47 | 8.47 |
| 180 | 467 | 176 | 1399 | 540 | 653859 | 1957201 | 252360 | 0.0004 | 1.000 | 7.39 | 7.39 |
| 190 | 493 | 202 | 1498 | 570 | 750582 | 2244004 | 285330 | 0.0003 | 1.000 | 6.66 | 6.66 |
| 200 | 538 | 247 | 1624 | 598 | 884142 | 2637376 | 324614 | 0.0002 | 1.000 | 5.93 | 5.93 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 208 | 593 | 302 | | | | | | | 1.000 | 5.39 | |
| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
| **RIFT – 17mm plywood full preheat time Test 2** | Ignition Time | 329 | | | | | | m/s | | kW/m² | |
| 10 | 0 | 0 | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 40 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |
| 60 | | | | | | | | | | | |
| 70 | | | | | | | | | | | |
| 80 | | | | | | | | | | | |
| 90 | | | | | | | | | | | |
| 100 | 337 | 8 | | | | | | | 1.000 | 16.68 | |
| 110 | 340 | 11 | 1026 | 330 | 350970 | 1052676 | 112980 | 0.0015 | 1.000 | 15.08 | 15.08 |
| 120 | 349 | 20 | 1048 | 360 | 366282 | 1098304 | 125950 | 0.0011 | 1.000 | 13.96 | 13.96 |
| 130 | 359 | 30 | 1079 | 390 | 388323 | 1164241 | 140490 | 0.0009 | 1.000 | 12.83 | 12.83 |
| 140 | 371 | 42 | 1115 | 420 | 414747 | 1243225 | 156360 | 0.0008 | 1.000 | 11.74 | 11.74 |
| 150 | 385 | 56 | 1159 | 450 | 448275 | 1343281 | 174170 | 0.0006 | 1.000 | 10.65 | 10.65 |
| 160 | 403 | 74 | 1276 | 480 | 548778 | 1628176 | 205190 | 0.0002 | 1.000 | 9.56 | 9.56 |
| 170 | 488 | 159 | 1408 | 510 | 667842 | 1982464 | 240500 | 0.0002 | 1.000 | 8.47 | 8.47 |
| 180 | 517 | 188 | 1497 | 540 | 747497 | 2241009 | 269500 | 0.0001 | 1.000 | 7.39 | 7.39 |
| 190 | 492 | 163 | 1538 | 570 | 789194 | 2365444 | 292340 | 0.0002 | 1.000 | 6.66 | 6.66 |
| 200 | 529 | 200 | 1588 | 600 | 843394 | 2521744 | 318350 | 0.0003 | 1.000 | 5.93 | 5.93 |
| 210 | 567 | 238 | 1699 | 630 | 964939 | 2886601 | 357530 | 0.0003 | 1.000 | 5.25 | 5.25 |
| 220 | 603 | 274 | 1796 | 653 | 1076974 | 3225616 | 391328 | 0.0002 | 1.000 | 4.62 | 4.62 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 223 | 626 | 297 | | | | | | | 1.000 | 4.43 | |
| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
| **RIFT – 17mm plywood full preheat time Test 3** | Ignition Time | 432 | | | | | | m/s | | kW/m² | |
| 10 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 40 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |
| 60 | | | | | | | | | | | |
| 70 | | | | | | | | | | | |
| 80 | | | | | | | | | | | |
| 90 | | | | | | | | | | | |
| 100 | 435 | 3 | | | | | | | 1.000 | 16.68 | |
| 110 | 442 | 10 | 1328 | 330 | 587990 | 1763584 | 146240 | 0.0012 | 1.000 | 15.08 | 15.08 |
| 120 | 451 | 19 | 1358 | 360 | 614990 | 1844164 | 163190 | 0.0009 | 1.000 | 13.96 | 13.96 |
| 130 | 465 | 33 | 1397 | 390 | 650987 | 1951609 | 181910 | 0.0007 | 1.000 | 12.83 | 12.83 |
| 140 | 481 | 49 | 1449 | 420 | 700595 | 2099601 | 203240 | 0.0005 | 1.000 | 11.74 | 11.74 |
| 150 | 503 | 71 | 1511 | 450 | 762099 | 2283121 | 227110 | 0.0004 | 1.000 | 10.65 | 10.65 |
| 160 | 527 | 95 | 1584 | 480 | 837654 | 2509056 | 253950 | 0.0004 | 1.000 | 9.56 | 9.56 |
| 170 | 554 | 122 | 1673 | 510 | 935109 | 2798929 | 285060 | 0.0003 | 1.000 | 8.47 | 8.47 |
| 180 | 592 | 160 | 1795 | 540 | 1078581 | 3222025 | 324050 | 0.0002 | 1.000 | 7.39 | 7.39 |
| 190 | 649 | 217 | 1955 | 570 | 1281461 | 3822025 | 372670 | 0.0002 | 1.000 | 6.66 | 6.66 |
| 200 | 714 | 282 | 2126 | 600 | 1513166 | 4519876 | 426340 | 0.0002 | 1.000 | 5.93 | 5.93 |
| 210 | 763 | 331 | 2306 | 630 | 1779206 | 5317636 | 485410 | 0.0002 | 1.000 | 5.25 | 5.25 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 220 | 829 | 397 | | | | | | | 1.000 | 4.62 | |
| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
| **RIFT – 17mm plywood full preheat time Test 4** | Ignition Time | 455 | | | | | | m/s | | kW/m² | |
| 10 | 0 | 0 | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | | | |
| 80 | 0 | 0 | | | | | | | | | |
| 90 | 0 | 0 | | | | | | | | | |
| 100 | 462 | 7 | | | | | | | | 16.68 | |
| 110 | 467 | 12 | 1402 | 330 | 655262 | 1965604 | 154330 | 0.0018 | 1.000 | 15.08 | 15.08 |
| 120 | 473 | 18 | 1420 | 360 | 672218 | 2016400 | 170530 | 0.0015 | 1.000 | 13.96 | 13.96 |
| 130 | 480 | 25 | 1442 | 390 | 693250 | 2079364 | 187620 | 0.0012 | 1.000 | 12.83 | 12.83 |
| 140 | 489 | 34 | 1469 | 420 | 719521 | 2157961 | 205860 | 0.0010 | 1.000 | 11.74 | 11.74 |
| 150 | 500 | 45 | 1505 | 450 | 755377 | 2265025 | 226020 | 0.0007 | 1.000 | 10.65 | 10.65 |
| 160 | 516 | 61 | 1550 | 480 | 801412 | 2402500 | 248340 | 0.0006 | 1.000 | 9.56 | 9.56 |
| 170 | 534 | 79 | 1609 | 510 | 863893 | 2588881 | 273960 | 0.0005 | 1.000 | 8.47 | 8.47 |
| 180 | 559 | 104 | 1678 | 540 | 939862 | 2815684 | 302550 | 0.0004 | 1.000 | 7.39 | 7.39 |
| 190 | 585 | 130 | 1766 | 570 | 1041590 | 3118756 | 336170 | 0.0003 | 1.000 | 6.66 | 6.66 |
| 200 | 622 | 167 | 1864 | 600 | 1160758 | 3474496 | 373520 | 0.0003 | 1.000 | 5.93 | 5.93 |
| 210 | 657 | 202 | 1961 | 630 | 1283657 | 3845521 | 412410 | 0.0003 | 1.000 | 5.25 | 5.25 |
| 220 | 682 | 227 | | | | | | | 1.000 | 4.62 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood full preheat time Test 5** | Ignition Time 432 | | | | | | | m/s | | kW/m² | |
| 10 | 0 | 0 | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | | | |
| 80 | 0 | 0 | | | | | | | | | |
| 90 | 0 | 0 | | | | | | | | | |
| 100 | 439 | 7 | | | | | | | | 16.68 | |
| 110 | 443 | 11 | 1331 | 330 | 590571 | 1771561 | 146510 | 0.0020 | 1.000 | 15.08 | 15.08 |
| 120 | 449 | 17 | 1350 | 360 | 607614 | 1822500 | 162150 | 0.0013 | 1.000 | 13.96 | 13.96 |
| 130 | 458 | 26 | 1375 | 390 | 630389 | 1890625 | 178940 | 0.0011 | 1.000 | 12.83 | 12.83 |
| 140 | 468 | 36 | 1405 | 420 | 658229 | 1974025 | 196910 | 0.0010 | 1.000 | 11.74 | 11.74 |
| 150 | 479 | 47 | 1441 | 450 | 692501 | 2076481 | 216410 | 0.0008 | 1.000 | 10.65 | 10.65 |
| 160 | 494 | 62 | 1483 | 480 | 733577 | 2199289 | 237590 | 0.0006 | 1.000 | 9.56 | 9.56 |
| 170 | 510 | 78 | 1537 | 510 | 788225 | 2362369 | 261680 | 0.0005 | 1.000 | 8.47 | 8.47 |
| 180 | 533 | 101 | 1611 | 540 | 866813 | 2595321 | 290560 | 0.0003 | 1.000 | 7.39 | 7.39 |
| 190 | 568 | 136 | 1714 | 570 | 982482 | 2937796 | 326460 | 0.0002 | 1.000 | 6.66 | 6.66 |
| 200 | 613 | 181 | 1842 | 600 | 1135314 | 3392964 | 369330 | 0.0002 | 1.000 | 5.93 | 5.93 |
| 210 | 661 | 229 | 2006 | 629 | 1348514 | 4024036 | 421718 | 0.0002 | 1.000 | 5.25 | 5.25 |
| 219 | 732 | 300 | | | | | | | 1.000 | 4.68 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – 17mm plywood full preheat time Test 6** | Ignition Time 432 | | | | | | | m/s | | kW/m² | |
| 10 | 0 | 0 | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | | | |
| 80 | 0 | 0 | | | | | | | | | |
| 90 | 0 | 0 | | | | | | | | | |
| 100 | 439 | 7 | | | | | | | 1.000 | 16.68 | |
| 110 | 443 | 11 | 1331 | 330 | 590571 | 1771561 | 146510 | 0.0020 | 1.000 | 15.08 | 15.08 |
| 120 | 449 | 17 | 1350 | 360 | 607614 | 1822500 | 162150 | 0.0013 | 1.000 | 13.96 | 13.96 |
| 130 | 458 | 26 | 1375 | 390 | 630389 | 1890625 | 178940 | 0.0011 | 1.000 | 12.83 | 12.83 |
| 140 | 468 | 36 | 1405 | 420 | 658229 | 1974025 | 196910 | 0.0010 | 1.000 | 11.74 | 11.74 |
| 150 | 479 | 47 | 1441 | 450 | 692501 | 2076481 | 216410 | 0.0008 | 1.000 | 10.65 | 10.65 |
| 160 | 494 | 62 | 1483 | 480 | 733577 | 2199289 | 237590 | 0.0006 | 1.000 | 9.56 | 9.56 |
| 170 | 510 | 78 | 1537 | 510 | 788225 | 2362369 | 261680 | 0.0005 | 1.000 | 8.47 | 8.47 |
| 180 | 533 | 101 | 1611 | 540 | 866813 | 2595321 | 290560 | 0.0003 | 1.000 | 7.39 | 7.39 |
| 190 | 568 | 136 | 1714 | 570 | 982482 | 2937796 | 326460 | 0.0002 | 1.000 | 6.66 | 6.66 |
| 200 | 613 | 181 | 1842 | 600 | 1135314 | 3392964 | 369330 | 0.0002 | 1.000 | 5.93 | 5.93 |
| 210 | 661 | 229 | 2006 | 629 | 1348514 | 4024036 | 421718 | 0.0002 | 1.000 | 5.25 | 5.25 |
| 219 | 732 | 300 | | | | | | | 1.000 | 4.68 | |

**Medium Density Fibreboard (MDF)**

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – 18mm MDF Test 1** | Ignition Time | 479 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | 479 | | | | | | | | | | | |
| 75 | 479 | | | | | | | | | | | |
| 100 | 479 | | | | | | | | | | | |
| 125 | 479 | | | | | | | | | | | |
| 150 | 479 | | | | | | | | | | | |
| 175 | 479 | | | | | | | | | | | |
| 200 | 479 | | | | | | | | | | | |
| 225 | 482 | 3 | | | | | | | | 18.54 | | |
| 250 | 488 | 9 | 1462 | 750 | 712532 | 2137444 | 365750 | 0.0049 | 1.000 | 17.25 | 17.25 | 14.236 |
| 275 | 492 | 13 | 1510 | 825 | 761108 | 2280100 | 416300 | 0.0010 | 1.000 | 15.85 | 15.85 | 31.992 |
| 300 | 530 | 51 | 1598 | 900 | 854740 | 2553604 | 481500 | 0.0006 | 1.000 | 14.45 | 14.45 | 41.050 |
| 325 | 576 | 97 | 1746 | 975 | 1022276 | 3048516 | 570200 | 0.0005 | 1.000 | 12.84 | 12.84 | 47.113 |
| 350 | 640 | 161 | 1924 | 1050 | 1242640 | 3701776 | 676700 | 0.0004 | 1.000 | 11.23 | 11.23 | 51.389 |
| 375 | 708 | 229 | 2159 | 1125 | 1568585 | 4661281 | 813900 | 0.0003 | 1.000 | 9.64 | 9.64 | 58.888 |
| 400 | 811 | 332 | 2461 | 1200 | 2046349 | 6056521 | 990250 | 0.0002 | 1.000 | 8.05 | 8.05 | 68.574 |
| 425 | 942 | 463 | 2887 | 1275 | 2831041 | 8334769 | 1235050 | 0.0002 | 1.000 | 7.01 | 7.01 | 80.850 |
| 450 | 1134 | 655 | 3308 | 1335 | 3691144 | 10942864 | 1477370 | 0.0001 | 1.000 | 5.97 | 5.97 | 90.534 |
| 460 | 1232 | 753 | | | | | | | 1.000 | 5.56 | 5.56 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition (s)* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f x}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – 18mm MDF Test 2** | Ignition Time | 478 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | 478 | | | | | | | | | | | |
| 75 | 478 | | | | | | | | | | | |
| 100 | 478 | | | | | | | | | | | |
| 125 | 478 | | | | | | | | | | | |
| 150 | 478 | | | | | | | | | | | |
| 175 | 478 | | | | | | | | | | | |
| 200 | 478 | | | | | | | | | | | |
| 225 | 478 | | | | | | | | | | | |
| 250 | 478 | | | | | | | | | | | |
| 275 | 487 | 9 | | | | | | | | 15.85 | | |
| 300 | 515 | 37 | 1558 | 900 | 811530 | 2427364 | 469125 | 0.0007 | 1.000 | 14.45 | 14.45 | 37.367 |
| 325 | 556 | 78 | 1678 | 975 | 942810 | 2815684 | 547650 | 0.0005 | 1.000 | 12.84 | 12.84 | 42.980 |
| 350 | 607 | 129 | 1850 | 1050 | 1149554 | 3422500 | 650775 | 0.0004 | 1.000 | 11.23 | 11.23 | 51.602 |
| 375 | 687 | 209 | 2098 | 1125 | 1486834 | 4401604 | 791675 | 0.0003 | 1.000 | 9.64 | 9.64 | 63.137 |
| 400 | 804 | 326 | 2418 | 1200 | 1977714 | 5846724 | 973200 | 0.0002 | 1.000 | 8.05 | 8.05 | 69.289 |
| 425 | 927 | 449 | 2820 | 1266 | 1712770 | 7952400 | 738325 | 0.0005 | 1.000 | 7.01 | 7.01 | 45.570 |
| 441 | 1089 | 611 | | | | | | | 1.000 | 6.35 | 6.35 | |

| Flame Front Position x | Time to position t | time from ignition | Σt | Σx | Σ(t²) | Σ(t)² | Σ(t.x) | V | F(t) | q” | q”.F(t) | 1/√V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – 18mm MDF Test 3** | Ignition Time | 455s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | 455 | | | | | | | | | | | |
| 75 | 455 | | | | | | | | | | | |
| 100 | 455 | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 125 | 455 | | | | | | | | | | | |
| 150 | 455 | | | | | | | | | | | |
| 175 | 455 | | | | | | | | | | | |
| 200 | 455 | | | | | | | | | | | |
| 225 | 455 | | | | | | | | | | | |
| 250 | 455 | | | | | | | | | | | |
| 275 | 466 | 11 | | | | | | | | 15.85 | | |
| 300 | 487 | 32 | 1478 | 900 | 729950 | 2184484 | 444875 | 0.0008 | 1.000 | 14.45 | 14.45 | 34.823 |
| 325 | 525 | 70 | 1589 | 975 | 845723 | 2524921 | 518675 | 0.0006 | 1.000 | 12.84 | 12.84 | 42.597 |
| 350 | 577 | 122 | 1740 | 1050 | 1015598 | 3027600 | 611825 | 0.0004 | 1.000 | 11.23 | 11.23 | 47.590 |
| 375 | 638 | 183 | 1950 | 1125 | 1280198 | 3802500 | 735200 | 0.0003 | 1.000 | 9.64 | 9.64 | 56.698 |
| 400 | 735 | 280 | 2232 | 1200 | 1685150 | 4981824 | 898325 | 0.0002 | 1.000 | 8.05 | 8.05 | 66.648 |
| 425 | 859 | 404 | 2618 | 1275 | 1278106 | 6853924 | 659075 | 0.0005 | 1.000 | 7.01 | 7.01 | 47.107 |
| 450 | 1024 | 569 | 2992 | 1332 | 1786457 | 8952064 | 825875 | 0.0004 | 1.000 | 5.97 | 5.97 | 48.815 |
| 457 | 1109 | 654 | | | | | | | 1.000 | 5.69 | 5.69 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF-RIFT - low preheat ISO ign data test 1** | Ignition Time | 69s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 69 | 0 | | | | | | | | 34.0 | | |
| 20 | 69 | 0 | 207 | 60 | 14283 | 42849 | 4140 | #DIV/0! | 0.441 | 33.1 | 14.57 | |
| 30 | 69 | 0 | 207 | 90 | 14283 | 42849 | 6210 | #DIV/0! | 0.441 | 32.5 | 14.31 | |
| 40 | 69 | 0 | 211 | 120 | 14851 | 44521 | 8480 | 0.0038 | 0.441 | 30.0 | 13.22 | 16.330 |
| 50 | 73 | 4 | 226 | 150 | 17146 | 51076 | 11450 | 0.0012 | 0.453 | 27.5 | 12.48 | 28.363 |
| 60 | 84 | 15 | 256 | 180 | 22186 | 65536 | 15620 | 0.0008 | 0.486 | 25.3 | 12.31 | 36.197 |
| 70 | 99 | 30 | 301 | 210 | 30781 | 90601 | 21410 | 0.0006 | 0.528 | 23.4 | 12.33 | 41.326 |
| 80 | 118 | 49 | 356 | 240 | 43046 | 126736 | 28880 | 0.0005 | 0.576 | 21.4 | 12.33 | 44.740 |
| 90 | 139 | 70 | 428 | 270 | 62486 | 183184 | 39050 | 0.0004 | 0.625 | 19.2 | 11.99 | 51.846 |
| 100 | 171 | 102 | 516 | 300 | 90998 | 266256 | 52270 | 0.0003 | 0.694 | 16.9 | 11.75 | 57.899 |
| 110 | 206 | 137 | 626 | 330 | 133678 | 391876 | 69640 | 0.0003 | 0.761 | 15.0 | 11.45 | 62.559 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 249 | 180 | 751 | 360 | 192053 | 564001 | 91020 | 0.0002 | 0.837 | 13.5 | 11.29 | 67.104 |
| 130 | 296 | 227 | 893 | 390 | 270721 | 797449 | 117080 | 0.0002 | 0.913 | 11.9 | 10.90 | 70.386 |
| 140 | 348 | 279 | 1052 | 420 | 375184 | 11067604 | 148400 | 0.0002 | 0.990 | 10.8 | 10.72 | 74.897 |
| 150 | 408 | 339 | 1243 | 450 | 524737 | 1545049 | 187840 | 0.0001 | 1.000 | 9.7 | 9.72 | 83.626 |
| 160 | 487 | 418 | | | | | | | 1.000 | 8.7 | 8.67 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF-RIFT - low preheat ISO ign data test 2** | Ignition Time | 60s | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| | | | | | | | | | | 34.9 | | |
| 10 | 60 | 0 | | | | | | | 0.411 | 34.0 | 13.96 | |
| 20 | 61 | 1 | 184 | 60 | 11290 | 33856 | 3710 | 0.0064 | 0.414 | 33.1 | 13.70 | 12.472 |
| 30 | 63 | 3 | 190 | 90 | 12046 | 36100 | 5750 | 0.0039 | 0.421 | 32.5 | 13.67 | 15.916 |
| 40 | 66 | 6 | 203 | 120 | 13801 | 41209 | 8230 | 0.0017 | 0.431 | 30.0 | 12.93 | 24.246 |
| 50 | 74 | 14 | 227 | 150 | 17401 | 51529 | 11560 | 0.0009 | 0.456 | 27.5 | 12.57 | 32.708 |
| 60 | 87 | 27 | 263 | 180 | 23449 | 69169 | 16060 | 0.0007 | 0.495 | 25.3 | 12.53 | 37.448 |
| 70 | 102 | 42 | 306 | 210 | 31662 | 93636 | 21720 | 0.0007 | 0.536 | 23.4 | 12.52 | 38.730 |
| 80 | 117 | 57 | 355 | 240 | 42589 | 126025 | 28740 | 0.0006 | 0.574 | 21.4 | 12.28 | 41.326 |
| 90 | 136 | 76 | 422 | 270 | 60746 | 178084 | 38500 | 0.0004 | 0.619 | 19.2 | 11.86 | 51.603 |
| 100 | 169 | 109 | 498 | 300 | 84306 | 248004 | 50370 | 0.0003 | 0.690 | 16.9 | 11.68 | 53.607 |
| 110 | 193 | 133 | 594 | 330 | 119634 | 352836 | 65970 | 0.0003 | 0.737 | 15.0 | 11.08 | 56.653 |
| 120 | 232 | 172 | 704 | 360 | 168914 | 495616 | 85340 | 0.0002 | 0.808 | 13.5 | 10.90 | 65.669 |
| 130 | 279 | 219 | 842 | 390 | 241226 | 708964 | 110450 | 0.0002 | 0.886 | 11.9 | 10.58 | 70.386 |
| 140 | 331 | 271 | 999 | 420 | 338723 | 998001 | 140960 | 0.0002 | 0.965 | 10.8 | 10.45 | 74.199 |
| 150 | 389 | 329 | 1183 | 450 | 475251 | 1399489 | 178770 | 0.0002 | 1.000 | 9.7 | 9.72 | 81.439 |
| 160 | 463 | 403 | 1341 | 320 | 369171 | 1798281 | 133020 | 0.0000 | 1.000 | 8.7 | 8.67 | 151.590 |
| 164 | 489 | 429 | | | | | | | 1.000 | 8.1 | 8.08 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e . F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF-RIFT - low preheat ISO ign data test 3** | Ignition Time | 59s | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 59 | 0 | | | | | | | 0.407 | 34.0 | | |
| 20 | 59 | 0 | 177 | 60 | 10443 | 31329 | 3540 | #DIV/0! | 0.407 | 33.1 | 13.47 | ! |
| 30 | 59 | 0 | 183 | 90 | 11187 | 33489 | 5550 | 0.0025 | 0.407 | 32.5 | 13.23 | 20.000 |
| 40 | 65 | 6 | 199 | 120 | 13331 | 39601 | 8120 | 0.0012 | 0.428 | 30.0 | 12.83 | 28.577 |
| 50 | 75 | 16 | 228 | 150 | 17594 | 51984 | 11630 | 0.0009 | 0.459 | 27.5 | 12.65 | 34.008 |
| 60 | 88 | 29 | 266 | 180 | 23978 | 70756 | 16240 | 0.0007 | 0.498 | 25.3 | 12.60 | 37.448 |
| 70 | 103 | 44 | 310 | 210 | 32514 | 96100 | 22010 | 0.0006 | 0.538 | 23.4 | 12.58 | 39.377 |
| 80 | 119 | 60 | 360 | 240 | 43814 | 129600 | 29150 | 0.0006 | 0.579 | 21.4 | 12.39 | 41.884 |
| 90 | 138 | 79 | 422 | 270 | 60430 | 178084 | 38440 | 0.0004 | 0.623 | 19.2 | 11.94 | 48.199 |
| 100 | 165 | 106 | 499 | 300 | 84685 | 249001 | 50480 | 0.0003 | 0.681 | 16.9 | 11.54 | 53.894 |
| 110 | 196 | 137 | 598 | 330 | 121810 | 357604 | 66500 | 0.0003 | 0.743 | 15.0 | 11.17 | 60.193 |
| 120 | 237 | 178 | 713 | 360 | 172985 | 508369 | 86400 | 0.0002 | 0.817 | 13.5 | 11.02 | 64.814 |
| 130 | 280 | 221 | 847 | 390 | 243469 | 717409 | 111040 | 0.0002 | 0.888 | 11.9 | 10.60 | 68.255 |
| 140 | 330 | 271 | 1001 | 420 | 340181 | 1002001 | 141250 | 0.0002 | 0.964 | 10.8 | 10.44 | 74.620 |
| 150 | 391 | 332 | 1199 | 450 | 490265 | 1437601 | 181330 | 0.0001 | 1.000 | 9.7 | 9.72 | 86.465 |
| 160 | 478 | 419 | 1397 | 370 | 388761 | 1951609 | 140290 | 0.0001 | 1.000 | 8.7 | 8.67 | 90.437 |
| 164 | 528 | 469 | | | | | | | 1.000 | 8.1 | 8.08 | |

| Flame Front Position x | Time to position t | time from ignition | Σt | Σx | Σ(t²) | Σ(t)² | Σ(t.x) | V | F(t) | q” | q”.F(t) | 1/√V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF-RIFT - low preheat ISO ign data test 4** | Ignition Time | 66s | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 66 | 0 | | | | | | | 0.431 | 34.0 | | |
| 20 | 67 | 1 | | 60 | 13469 | 0 | 4040 | 0.0003 | 0.434 | 33.1 | 14.36 | 57.740 |
| 30 | 68 | 2 | | 90 | 14013 | 0 | 6180 | 0.0004 | 0.437 | 32.5 | 14.20 | 47.618 |
| 40 | 70 | 4 | 212 | 120 | 15000 | 44944 | 8540 | 0.0032 | 0.444 | 30.0 | 13.32 | 17.638 |
| 50 | 74 | 8 | 230 | 150 | 17772 | 52900 | 11660 | 0.0012 | 0.456 | 27.5 | 12.57 | 29.439 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 86 | 20 | 260 | 180 | 22872 | 67600 | 15860 | 0.0008 | 0.492 | 25.3 | 12.46 | 36.091 |
| 70 | 100 | 34 | 304 | 210 | 31320 | 92416 | 21600 | 0.0006 | 0.530 | 23.4 | 12.39 | 40.104 |
| 80 | 118 | 52 | 355 | 240 | 42693 | 126025 | 28770 | 0.0005 | 0.576 | 21.4 | 12.33 | 43.017 |
| 90 | 137 | 71 | 422 | 270 | 60582 | 178084 | 38470 | 0.0004 | 0.621 | 19.2 | 11.90 | 49.911 |
| 100 | 167 | 101 | 502 | 300 | 85862 | 252004 | 50810 | 0.0003 | 0.686 | 16.9 | 11.61 | 55.229 |
| 110 | 198 | 132 | 602 | 330 | 123262 | 362404 | 66920 | 0.0003 | 0.746 | 15.0 | 11.23 | 59.289 |
| 120 | 237 | 171 | 714 | 360 | 173214 | 509796 | 86490 | 0.0002 | 0.817 | 13.5 | 11.02 | 63.654 |
| 130 | 279 | 213 | 853 | 390 | 247579 | 727609 | 111890 | 0.0002 | 0.886 | 11.9 | 10.58 | 71.012 |
| 140 | 337 | 271 | 1010 | 420 | 346646 | 1020100 | 142550 | 0.0002 | 0.974 | 10.8 | 10.55 | 75.830 |
| 150 | 394 | 328 | 1257 | 450 | 545481 | 1580049 | 190440 | 0.0001 | 1.000 | 9.7 | 9.72 | 99.730 |
| 160 | 526 | 460 | 1460 | 473 | 723512 | 2131600 | 231280 | 0.0001 | 1.000 | 8.7 | 8.67 | 109.287 |
| 163 | 540 | 474 | | | | | | | 1.000 | 8.2 | 8.23 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF-RIFT - low preheat ISO ign data test 5** | Ignition Time | 61s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 61 | 0 | | | | | | | 0.414 | 34.0 | 14.08 | |
| 20 | 62 | 1 | 187 | 60 | 11661 | 34969 | 3770 | 0.0064 | 0.418 | 33.1 | 13.81 | 12.472 |
| 30 | 64 | 3 | 195 | 90 | 12701 | 38025 | 5920 | 0.0027 | 0.424 | 32.5 | 13.78 | 19.272 |
| 40 | 69 | 8 | 207 | 120 | 14333 | 42849 | 8380 | 0.0020 | 0.441 | 30.0 | 13.22 | 22.361 |
| 50 | 74 | 13 | 229 | 150 | 17633 | 52441 | 11620 | 0.0011 | 0.456 | 27.5 | 12.57 | 29.967 |
| 60 | 86 | 25 | 259 | 180 | 22673 | 67081 | 15790 | 0.0008 | 0.492 | 25.3 | 12.46 | 35.365 |
| 70 | 99 | 38 | 305 | 210 | 31597 | 93025 | 21690 | 0.0006 | 0.528 | 23.4 | 12.33 | 41.610 |
| 80 | 120 | 59 | 360 | 240 | 44082 | 129600 | 29220 | 0.0005 | 0.581 | 21.4 | 12.44 | 45.826 |
| 90 | 141 | 80 | 432 | 270 | 63522 | 186624 | 39390 | 0.0004 | 0.630 | 19.2 | 12.07 | 50.759 |
| 100 | 171 | 110 | 513 | 300 | 89523 | 263169 | 51900 | 0.0003 | 0.694 | 16.9 | 11.75 | 54.772 |
| 110 | 201 | 140 | 614 | 330 | 128206 | 376996 | 68250 | 0.0003 | 0.752 | 15.0 | 11.31 | 59.820 |
| 120 | 242 | 181 | 731 | 360 | 181909 | 534361 | 88590 | 0.0002 | 0.825 | 13.5 | 11.13 | 65.991 |
| 130 | 288 | 227 | 875 | 390 | 260533 | 765625 | 114780 | 0.0002 | 0.900 | 11.9 | 10.75 | 71.900 |
| 140 | 345 | 284 | 1037 | 420 | 365185 | 1075369 | 146340 | 0.0002 | 0.985 | 10.8 | 10.67 | 76.162 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 404 | 343 | 1230 | 450 | 513602 | 1512900 | 185860 | 0.0001 | 1.000 | 9.7 | 9.72 | 82.703 |
| 160 | 481 | 420 | 1439 | 472 | 701493 | 2070721 | 227308 | 0.0001 | 1.000 | 8.7 | 8.67 | 111.487 |
| 162 | 554 | 493 | | | | | | | 1.000 | 8.4 | 8.37 | |
| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
| **MDF-RIFT - low preheat. ISO ign data test 6** | Ignition Time | 68s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 68 | 0 | | | | | | | 0.437 | 34.0 | 14.86 | |
| 20 | 68.5 | 0.5 | 206 | 60 | 14077 | 42230 | 4120 | 0.0200 | 0.439 | 33.1 | 14.52 | 7.071 |
| 30 | 69 | 1 | 208 | 90 | 14353 | 43056 | 6240 | 0.0129 | 0.441 | 32.5 | 14.31 | 8.819 |
| 40 | 70 | 2 | 215 | 120 | 15437 | 46225 | 8670 | 0.0024 | 0.444 | 30.0 | 13.32 | 20.237 |
| 50 | 76 | 8 | 237 | 150 | 18957 | 56169 | 12060 | 0.0009 | 0.462 | 27.5 | 12.74 | 33.381 |
| 60 | 91 | 23 | 271 | 180 | 24873 | 73441 | 16540 | 0.0007 | 0.506 | 25.3 | 12.82 | 37.448 |
| 70 | 104 | 36 | 315 | 210 | 33497 | 99225 | 22340 | 0.0007 | 0.541 | 23.4 | 12.64 | 38.147 |
| 80 | 120 | 52 | 366 | 240 | 45380 | 133956 | 29660 | 0.0005 | 0.581 | 21.4 | 12.44 | 43.770 |
| 90 | 142 | 74 | 433 | 270 | 63805 | 187489 | 39480 | 0.0004 | 0.632 | 19.2 | 12.12 | 50.656 |
| 100 | 171 | 103 | 515 | 300 | 90209 | 265225 | 52100 | 0.0003 | 0.694 | 16.9 | 11.75 | 54.782 |
| 110 | 202 | 134 | 614 | 330 | 128126 | 376996 | 68240 | 0.0003 | 0.754 | 15.0 | 11.34 | 59.289 |
| 120 | 241 | 173 | 725 | 360 | 178409 | 525625 | 87800 | 0.0002 | 0.824 | 13.5 | 11.11 | 63.252 |
| 130 | 282 | 214 | 857 | 390 | 249161 | 734449 | 112340 | 0.0002 | 0.891 | 11.9 | 10.64 | 68.350 |
| 140 | 334 | 266 | 1012 | 420 | 347896 | 1024144 | 142820 | 0.0002 | 0.969 | 10.8 | 10.50 | 75.595 |
| 150 | 396 | 328 | 1196 | 450 | 485528 | 1430416 | 180720 | 0.0002 | 1.000 | 9.7 | 9.72 | 81.290 |
| 160 | 466 | 398 | 1389 | 475 | 651701 | 1929321 | 220915 | 0.0001 | 1.000 | 8.7 | 8.67 | 93.171 |
| 165 | 527 | 459 | | | | | | | 1.000 | 7.9 | 7.93 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF – RIFT –Full preheat Test 1** | Ignition Time | 364s | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 369 | 5 | | | | | | | 1.000 | 16.9 | | |
| 110 | 382 | 18 | 1154 | 330 | 444494 | 1331716 | 127280 | 0.0006 | 1.000 | 15.0 | 15.04 | 41.610 |
| 120 | 403 | 39 | 1221 | 360 | 498429 | 1490841 | 147060 | 0.0004 | 1.000 | 13.5 | 13.49 | 52.387 |
| 130 | 436 | 72 | 1317 | 390 | 580989 | 1734489 | 171960 | 0.0003 | 1.000 | 11.9 | 11.95 | 61.384 |
| 140 | 478 | 114 | 1441 | 420 | 696309 | 2076481 | 202650 | 0.0002 | 1.000 | 10.8 | 10.83 | 67.520 |
| 150 | 527 | 163 | 1593 | 450 | 851957 | 2537649 | 240050 | 0.0002 | 1.000 | 9.7 | 9.72 | 74.309 |
| 160 | 588 | 224 | 1774 | 480 | 1057754 | 3147076 | 285160 | 0.0002 | 1.000 | 8.7 | 8.67 | 81.318 |
| 170 | 659 | 295 | 1969 | 510 | 1301309 | 3876961 | 336070 | 0.0001 | 1.000 | 7.7 | 7.68 | 81.902 |
| 180 | 722 | 358 | | | | | | | | 6.7 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF – RIFT –Full preheat Test 2** | Ignition Time | 357s | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 365 | 8 | | | | | | | | 16.9 | | |
| 110 | 382 | 25 | 1149 | 330 | 440753 | 1320201 | 126760 | 0.0005 | 1.000 | 15.0 | 15.04 | 43.059 |
| 120 | 402 | 45 | 1222 | 360 | 499372 | 1493284 | 147200 | 0.0003 | 1.000 | 13.5 | 13.49 | 53.630 |
| 130 | 438 | 81 | 1313 | 390 | 577177 | 1723969 | 171400 | 0.0003 | 1.000 | 11.9 | 11.95 | 59.584 |
| 140 | 473 | 116 | 1434 | 420 | 689102 | 2056356 | 201610 | 0.0002 | 1.000 | 10.8 | 10.83 | 65.530 |
| 150 | 523 | 166 | 1574 | 450 | 831342 | 2477476 | 237150 | 0.0002 | 1.000 | 9.7 | 9.72 | 72.484 |
| 160 | 578 | 221 | 1742 | 480 | 1018494 | 3034564 | 279900 | 0.0002 | 1.000 | 8.7 | 8.67 | 76.870 |
| 170 | 641 | 284 | 1920 | 340 | 744965 | 3686400 | 201450 | 0.0000 | 1.000 | 7.7 | 7.68 | 173.086 |
| 180 | 701 | 344 | 2091 | 535 | 1463283 | 4372281 | 373715 | 0.0001 | 1.000 | 6.7 | 6.70 | 84.507 |
| 185 | 749 | 392 | | | | | | | | 6.2 | | |
| Flame Front Position x | Time to position t | time from ignition | Σt | Σx | Σ(t²) | Σ(t)² | Σ(t.x) | V | F(t) | q” | q”.F(t) | 1/√V |
| **MDF – RIFT –Full preheat Test 3** | Ignition Time | 359s | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 365 | 6 | | | | | | | 1.000 | 16.9 | | |
| 110 | 378 | 19 | 1165 | 330 | 454193 | 1357225 | 128720 | 0.0003 | 1.000 | 15.0 | 15.04 | 55.955 |
| 120 | 422 | 63 | 1257 | 360 | 529817 | 1580049 | 151630 | 0.0003 | 1.000 | 13.5 | 13.49 | 62.985 |
| 130 | 457 | 98 | 1374 | 390 | 631958 | 1887876 | 179350 | 0.0003 | 1.000 | 11.9 | 11.95 | 60.432 |
| 140 | 495 | 136 | 1476 | 420 | 728450 | 2178576 | 207310 | 0.0003 | 1.000 | 10.8 | 10.83 | 58.053 |
| 150 | 524 | 165 | 1592 | 450 | 847930 | 2534464 | 239580 | 0.0003 | 1.000 | 9.7 | 9.72 | 63.131 |
| 160 | 573 | 214 | 1734 | 370 | 602905 | 3006756 | 170280 | 0.0001 | 1.000 | 8.7 | 8.67 | 95.726 |
| 170 | 637 | 278 | 1910 | 510 | 1224098 | 3648100 | 325970 | 0.0002 | 1.000 | 7.7 | 7.68 | 79.688 |
| 180 | 700 | 341 | 2085 | 535 | 1455273 | 4347225 | 372670 | 0.0001 | 1.000 | 6.7 | 6.70 | 85.644 |
| 185 | 748 | 389 | | | | | | | | 6.2 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF – RIFT –Full preheat Test 4** | Ignition Time | 358s | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 366 | 8 | | | | | | | | 16.9 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 110 | 380 | 22 | 1148 | 330 | 439960 | 1317904 | 126640 | 0.0005 | 1.000 | 15.0 | 15.04 | 42.774 |
| 120 | 402 | 44 | 1213 | 360 | 491765 | 1471369 | 146070 | 0.0004 | 1.000 | 13.5 | 13.49 | 50.656 |
| 130 | 431 | 73 | 1304 | 390 | 569206 | 1700416 | 170210 | 0.0003 | 1.000 | 11.9 | 11.95 | 58.985 |
| 140 | 471 | 113 | 1423 | 420 | 679043 | 2024929 | 200120 | 0.0002 | 1.000 | 10.8 | 10.83 | 67.220 |
| 150 | 521 | 163 | 1573 | 450 | 830843 | 2474329 | 237050 | 0.0002 | 1.000 | 9.7 | 9.72 | 74.264 |
| 160 | 581 | 223 | 1735 | 480 | 1009691 | 3010225 | 278720 | 0.0002 | 1.000 | 8.7 | 8.67 | 74.897 |
| 170 | 633 | 275 | 1903 | 510 | 1212971 | 3621409 | 324590 | 0.0002 | 1.000 | 7.7 | 7.68 | 73.501 |
| 180 | 689 | 331 | 2046 | 534 | 1399586 | 4186116 | 364846 | 0.0002 | 1.000 | 6.7 | 6.70 | 80.027 |
| 184 | 724 | 366 | | | | | | | 1.000 | 6.3 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MDF – RIFT –Full preheat Test 5** | Ignition Time | 367s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 377 | 10 | | | | | | | 1.000 | 16.9 | | |
| 110 | 395 | 28 | 1189 | 330 | 472043 | 1413721 | 131190 | 0.0005 | 1.000 | 15.0 | 15.04 | 44.796 |
| 120 | 417 | 50 | 1266 | 360 | 536030 | 1602756 | 152510 | 0.0003 | 1.000 | 13.5 | 13.49 | 54.896 |
| 130 | 454 | 87 | 1370 | 390 | 629006 | 1876900 | 178920 | 0.0002 | 1.000 | 11.9 | 11.95 | 64.133 |
| 140 | 499 | 132 | 1504 | 420 | 758718 | 2262016 | 211530 | 0.0002 | 1.000 | 10.8 | 10.83 | 69.702 |
| 150 | 551 | 184 | 1664 | 450 | 929598 | 2768896 | 250750 | 0.0002 | 1.000 | 9.7 | 9.72 | 75.944 |
| 160 | 614 | 247 | 1848 | 480 | 1147086 | 3415104 | 297000 | 0.0002 | 1.000 | 8.7 | 8.67 | 81.268 |
| 170 | 683 | 316 | 2050 | 509 | 1410494 | 4202500 | 349137 | 0.0001 | 1.000 | 7.7 | 7.68 | 85.539 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 179 | 753 | 386 | | | | | | | 1.000 | 6.5 | | |
| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
| **MDF – RIFT –Full preheat Test 6** | Ignition Time | 358s | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 366 | 8 | | | | | | | 1.000 | 16.9 | | |
| 110 | 381 | 23 | 1151 | 330 | 442333 | 1324801 | 126990 | 0.0005 | 1.000 | 15.0 | 15.04 | 43.910 |
| 120 | 404 | 46 | 1219 | 360 | 496733 | 1485961 | 146810 | 0.0004 | 1.000 | 13.5 | 13.49 | 51.628 |
| 130 | 434 | 76 | 1328 | 390 | 591672 | 1763584 | 173500 | 0.0002 | 1.000 | 11.9 | 11.95 | 66.566 |
| 140 | 490 | 132 | 1454 | 420 | 709356 | 2114116 | 204520 | 0.0002 | 1.000 | 10.8 | 10.83 | 69.602 |
| 150 | 530 | 172 | 1606 | 450 | 864396 | 2579236 | 241860 | 0.0002 | 1.000 | 9.7 | 9.72 | 69.602 |
| 160 | 586 | 228 | 1788 | 480 | 1075880 | 3196944 | 287500 | 0.0001 | 1.000 | 8.7 | 8.67 | 84.886 |
| 170 | 672 | 314 | 1972 | 510 | 1304776 | 3888784 | 336520 | 0.0002 | 1.000 | 7.7 | 7.68 | 81.560 |
| 180 | 714 | 356 | 2160 | 540 | 1560456 | 4665600 | 389820 | 0.0002 | 1.000 | 6.7 | 6.70 | 71.784 |
| 190 | 774 | 416 | | | | | | | 1.000 | 6.0 | | |

**Melteca/ MDF**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Melteca /MDF- test 1** | Ignition Time | 498s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | 0.000 | 35.4 | 0.00 | |
| 100 | | | | | | | | | 0.000 | 35.0 | 0.00 | |
| 125 | | | | | | | | | 0.000 | 33.7 | 0.00 | |
| 150 | | | | | | | | | 0.000 | 32.4 | 0.00 | |
| 175 | | | | | | | | | 0.000 | 30.7 | 0.00 | |
| 200 | | | | | | | | | 0.000 | 29.0 | 0.00 | |
| 225 | | | | | | | | | 0.000 | 27.4 | 0.00 | |
| 250 | | | | | | | | | 0.000 | 25.7 | 0.00 | |
| 275 | | | | | | | | | 0.000 | 23.3 | 0.00 | |
| 300 | 518 | 20 | | | | | | | 0.962 | 20.9 | 20.10 | |
| 325 | 569 | 71 | 1697 | 975 | 964185 | 2879809 | 553825 | 0.0005 | 1.000 | 19.2 | 19.20 | 42.980 |
| 350 | 610 | 112 | 1966 | 1050 | 1315230 | 3865156 | 693550 | 0.0002 | 1.000 | 17.5 | 17.50 | 70.183 |
| 375 | 787 | 289 | 2286 | 1125 | 1781790 | 5225796 | 864225 | 0.0002 | 1.000 | 14.9 | 14.90 | 75.594 |
| 400 | 889 | 391 | 2840 | 1200 | 2764586 | 8065600 | 1145425 | 0.0001 | 1.000 | 12.3 | 12.30 | 89.829 |
| 425 | 1164 | 666 | 3463 | 1270 | 4133317 | 11992369 | 1477750 | 0.0001 | 1.000 | 10.9 | 10.90 | 107.545 |
| 445 | 1410 | 912 | | | | | | | 1.000 | 9.8 | 9.78 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Melteca /MDF- test 2** | Ignition Time | 518s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | 563 | 45 | | | | | | | 1.000 | 35.0 | 35.00 | |
| 125 | 566 | 48 | 1702 | 375 | 965654 | 2896804 | 213000 | 0.00475 | 1.000 | 33.7 | 33.70 | 14.514 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 573 | 55 | 1720 | 450 | 986246 | 2958400 | 258375 | 0.00333 | 1.000 | 32.4 | 32.40 | 17.333 |
| 175 | 581 | 63 | 1746 | 525 | 1016354 | 3048516 | 306025 | 0.00261 | 1.000 | 30.7 | 30.70 | 19.574 |
| 200 | 592 | 74 | 1773 | 600 | 1048025 | 3143529 | 355075 | 0.00261 | 1.000 | 29.0 | 29.00 | 19.574 |
| 225 | 600 | 82 | 1802 | 675 | 1082564 | 3247204 | 405900 | 0.00277 | 1.000 | 27.4 | 27.35 | 19.013 |
| 250 | 610 | 92 | 1830 | 750 | 1116500 | 3348900 | 458000 | 0.00250 | 1.000 | 25.7 | 25.70 | 20.000 |
| 275 | 620 | 102 | 1865 | 825 | 1159725 | 3478225 | 513500 | 0.00197 | 1.000 | 23.3 | 23.30 | 22.509 |
| 300 | 635 | 117 | 1969 | 900 | 1297421 | 3876961 | 593050 | 0.00046 | 1.000 | 20.9 | 20.90 | 46.589 |
| 325 | 714 | 196 | 2134 | 975 | 1529246 | 4553956 | 697300 | 0.00033 | 1.000 | 19.2 | 19.20 | 54.798 |
| 350 | 785 | 267 | 2387 | 1050 | 1914565 | 5697769 | 839800 | 0.00028 | 1.000 | 17.5 | 17.50 | 59.323 |
| 375 | 888 | 370 | 2743 | 1125 | 2549669 | 7524049 | 1035750 | 0.00017 | 1.000 | 14.9 | 14.90 | 76.459 |
| 400 | 1070 | 552 | 3196 | 1200 | 3466088 | 10214416 | 1287150 | 0.00014 | 1.000 | 12.3 | 12.30 | 83.688 |
| 425 | 1238 | 720 | 3826 | 1265 | 4981868 | 14638276 | 1622070 | 0.00009 | 1.000 | 10.9 | 10.90 | 108.058 |
| 440 | 1518 | 1000 | | | | | | | 1.000 | 10.1 | 10.06 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Melteca /MDF- test 3** | Ignition Time | 60 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | 0.000 | 35.4 | | |
| 100 | | | | | | | | | 0.000 | 35.0 | | |
| 125 | | | | | | | | | 0.000 | 33.7 | | |
| 150 | | | | | | | | | 0.000 | 32.4 | | |
| 175 | | | | | | | | | 0.000 | 30.7 | | |
| 200 | | | | | | | | | 0.000 | 29.0 | | |
| 225 | | | | | | | | | 0.000 | 27.4 | | |
| 250 | | | | | | | | | 0.000 | 25.7 | | |
| 275 | 580 | 62 | | | | | | | 1.000 | 23.3 | | |
| 300 | 605 | 87 | 1842 | 900 | 1134074 | 3392964 | 554525 | 0.0006 | 1.000 | 20.9 | 20.90 | 40.039 |
| 325 | 657 | 139 | 1987 | 975 | 1323299 | 3948169 | 648775 | 0.0004 | 1.000 | 19.2 | 19.20 | 49.135 |
| 350 | 725 | 207 | 2210 | 1050 | 1642858 | 4884100 | 777775 | 0.0003 | 1.000 | 17.5 | 17.50 | 58.888 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 375 | 828 | 310 | 2638 | 1125 | 2388434 | 6959044 | 998250 | 0.0001 | 1.000 | 14.9 | 14.90 | 87.402 |
| 400 | 1085 | 567 | 3383 | 1200 | 4023709 | 11444689 | 1369250 | 0.0001 | 1.000 | 12.3 | 12.30 | 114.062 |
| 425 | 1470 | 952 | | | | | | | 1.000 | 10.9 | 10.90 | |
| 445 | 1675 | 1157 | | | | | | | 1.000 | 9.8 | 9.78 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT Melteca/MDF low preheat-test 1** | Ignition Time | 75s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 75 | 0 | | | | | | | 0.372 | 34.25 | 12.74 | |
| 20 | 78 | 3 | 234 | 60 | 18270 | 54756 | 4740 | 0.0033 | 0.379 | 33.40 | 12.67 | 17.321 |
| 30 | 81 | 6 | 243 | 90 | 19701 | 59049 | 7350 | 0.0033 | 0.386 | 31.99 | 12.36 | 17.321 |
| 40 | 84 | 9 | 260 | 120 | 22642 | 67600 | 10540 | 0.0013 | 0.394 | 29.45 | 11.59 | 27.860 |
| 50 | 95 | 20 | 351 | 150 | 45665 | 123201 | 18430 | 0.0002 | 0.418 | 27.00 | 11.30 | 72.284 |
| 60 | 172 | 97 | 472 | 180 | 80634 | 222784 | 29420 | 0.0002 | 0.563 | 24.80 | 13.97 | 76.114 |
| 70 | 205 | 130 | 628 | 210 | 134610 | 394384 | 44750 | 0.0003 | 0.615 | 22.75 | 13.98 | 63.132 |
| 80 | 251 | 176 | 756 | 240 | 195026 | 571536 | 61430 | 0.0002 | 0.680 | 20.62 | 14.03 | 68.932 |
| 90 | 300 | 225 | 896 | 270 | 272026 | 802816 | 81580 | 0.0002 | 0.744 | 18.39 | 13.67 | 68.577 |
| 100 | 345 | 270 | 1069 | 300 | 388801 | 1142761 | 108140 | 0.0002 | 0.797 | 16.28 | 12.99 | 79.721 |
| 110 | 424 | 349 | 1331 | 330 | 614645 | 1771561 | 148580 | 0.0001 | 0.884 | 14.50 | 12.82 | 105.439 |
| 120 | 562 | 487 | | | | | | | 1.000 | 12.91 | 12.91 | |

| Flame Front Position x | Time to position t | time from ignition | Σt | Σx | Σ(t²) | Σ(t)² | Σ(t.x) | V | F(t) | q” | q”.F(t) | 1/√V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT Melteca/MDF low preheat-test 2** | Ignition Time | 48s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 48 | 0 | | | | | | | | 34.25 | | |
| 20 | 76 | 28 | 227 | 60 | 18689 | 51529 | 5090 | 0.00036 | 0.374 | 33.40 | 12.50 | 52.443 |
| 30 | 103 | 55 | 321 | 90 | 36549 | 103041 | 10290 | 0.00030 | 0.436 | 31.99 | 13.94 | 57.761 |
| 40 | 142 | 94 | 415 | 120 | 59673 | 172225 | 17270 | 0.00030 | 0.512 | 29.45 | 15.07 | 58.139 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 170 | 122 | 505 | 150 | 86313 | 255025 | 25760 | 0.00039 | 0.560 | 27.00 | 15.12 | 50.578 |
| 60 | 193 | 145 | 595 | 180 | 119973 | 354025 | 36320 | 0.00032 | 0.596 | 24.80 | 14.79 | 56.292 |
| 70 | 232 | 184 | 683 | 210 | 157637 | 466489 | 48460 | 0.00030 | 0.654 | 22.75 | 14.88 | 57.388 |
| 80 | 258 | 210 | 786 | 240 | 208004 | 617796 | 63520 | 0.00031 | 0.690 | 20.62 | 14.22 | 56.899 |
| 90 | 296 | 248 | 948 | 270 | 309416 | 898704 | 86680 | 0.00014 | 0.739 | 18.39 | 13.58 | 85.095 |
| 100 | 394 | 346 | 1218 | 300 | 521636 | 1483524 | 124120 | 0.00009 | 0.852 | 16.28 | 13.88 | 108.135 |
| 110 | 528 | 480 | 1522 | 330 | 794020 | 2316484 | 169480 | 0.00009 | 0.987 | 14.50 | 14.30 | 103.010 |
| 120 | 600 | 552 | 1848 | 359 | 1157184 | 3415104 | 222960 | 0.00010 | 1.000 | 12.91 | 12.91 | 101.790 |
| 129 | 720 | 672 | | | | | | | 1.000 | 12.97 | 12.97 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT Melteca/MDF-low preheat-test 3** | Ignition Time | 60s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | | | | |
| 20 | 94 | 34 | 275 | 60 | 27077 | 75625 | 6110 | 0.0003 | 0.416 | 33.40 | 13.90 | 55.348 |
| 30 | 121 | 61 | 358 | 90 | 43926 | 128164 | 11230 | 0.0004 | 0.472 | 31.99 | 15.11 | 49.583 |
| 40 | 143 | 83 | 453 | 120 | 70811 | 205209 | 18800 | 0.0003 | 0.513 | 29.45 | 15.12 | 59.508 |
| 50 | 189 | 129 | 558 | 150 | 107246 | 311364 | 28730 | 0.0002 | 0.590 | 27.00 | 15.94 | 64.547 |
| 60 | 226 | 166 | 664 | 180 | 148798 | 440896 | 40440 | 0.0003 | 0.645 | 24.80 | 16.01 | 55.267 |
| 70 | 249 | 189 | 758 | 210 | 193166 | 574564 | 53630 | 0.0003 | 0.677 | 22.75 | 15.41 | 53.716 |
| 80 | 283 | 223 | 859 | 240 | 249019 | 737881 | 69500 | 0.0003 | 0.722 | 20.62 | 14.89 | 62.621 |
| 90 | 327 | 267 | 985 | 270 | 327643 | 970225 | 89570 | 0.0002 | 0.776 | 18.39 | 14.28 | 67.845 |
| 100 | 375 | 315 | 1172 | 300 | 468454 | 1373584 | 118630 | 0.0001 | 0.831 | 16.28 | 13.54 | 86.067 |
| 110 | 470 | 410 | 1389 | 330 | 657461 | 1929321 | 154480 | 0.0001 | 0.931 | 14.50 | 13.50 | 92.160 |
| 120 | 544 | 484 | 1633 | 353 | 899997 | 2666689 | 193117 | 0.0001 | 1.000 | 12.91 | 12.91 | 107.124 |
| 123 | 619 | 559 | | | | | | | 1.000 | 13.35 | 13.35 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT Melteca/MDF-low preheat-test 4** | Ignition Time | 60s | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | 60 | 0 | 153 | 30 | 12249 | 23409 | 2460 | 0.0002 | 0.333 | 34.64 | 11.52 | 69.142 |
| 20 | 93 | 33 | 273 | 60 | 26649 | 74529 | 6060 | 0.0003 | 0.414 | 33.67 | 13.94 | 54.863 |
| 30 | 120 | 60 | 355 | 90 | 43213 | 126025 | 11140 | 0.0004 | 0.470 | 33.00 | 15.52 | 49.583 |
| 40 | 142 | 82 | 448 | 120 | 69160 | 200704 | 18580 | 0.0003 | 0.512 | 30.46 | 15.59 | 58.500 |
| 50 | 186 | 126 | 518 | 150 | 90860 | 268324 | 26380 | 0.0003 | 0.586 | 27.92 | 16.35 | 54.365 |
| 60 | 190 | 130 | 596 | 180 | 119096 | 355216 | 36100 | 0.0005 | 0.592 | 25.63 | 15.17 | 45.071 |
| 70 | 220 | 160 | 664 | 210 | 149016 | 440896 | 47120 | 0.0003 | 0.637 | 23.57 | 15.01 | 56.605 |
| 80 | 254 | 194 | 779 | 240 | 205941 | 606841 | 63170 | 0.0002 | 0.684 | 21.51 | 14.72 | 65.625 |
| 90 | 305 | 245 | 928 | 270 | 293702 | 861184 | 84670 | 0.0002 | 0.750 | 19.28 | 14.46 | 75.990 |
| 100 | 369 | 309 | 1208 | 300 | 514342 | 1459264 | 123090 | 0.0001 | 0.825 | 17.05 | 14.06 | 110.419 |
| 110 | 534 | 474 | 1526 | 329 | 809446 | 2328676 | 169777 | 0.0001 | 0.992 | 15.14 | 15.02 | 117.028 |
| 119 | 623 | 563 | | | | | | | 1.000 | 15.14 | 15.14 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT Melteca/MDF-low preheat-test 5** | Ignition Time | 65s | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | 65 | 0 | | | | | | | | | | |
| 20 | 105 | 40 | 297 | 60 | 31379 | 88209 | 6560 | 0.0003 | 0.440 | 33.67 | 14.81 | 56.454 |
| 30 | 127 | 62 | 406 | 90 | 57430 | 164836 | 12870 | 0.0003 | 0.484 | 33.00 | 15.97 | 60.008 |
| 40 | 174 | 109 | 491 | 120 | 82505 | 241081 | 20270 | 0.0003 | 0.566 | 30.46 | 17.25 | 58.346 |
| 50 | 190 | 125 | 599 | 150 | 121601 | 358801 | 30560 | 0.0003 | 0.592 | 27.92 | 16.53 | 57.269 |
| 60 | 235 | 170 | 705 | 180 | 169725 | 497025 | 43200 | 0.0002 | 0.658 | 25.63 | 16.87 | 67.082 |
| 70 | 280 | 215 | 846 | 210 | 243186 | 715716 | 60180 | 0.0002 | 0.718 | 23.57 | 16.93 | 69.327 |
| 80 | 331 | 266 | 1031 | 240 | 364361 | 1062961 | 83880 | 0.0001 | 0.781 | 21.51 | 16.81 | 84.687 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | 420 | 355 | 1238 | 270 | 523130 | 1532644 | 112980 | 0.0001 | 0.880 | 19.28 | 16.97 | 88.610 |
| 100 | 487 | 422 | 1563 | 298 | 843905 | 2442969 | 157348 | 0.0001 | 0.947 | 17.05 | 16.15 | 118.971 |
| 108 | 656 | 591 | | | | | | | 1.000 | 17.05 | 17.05 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT Melteca/MDF-low preheat-test 6** | Ignition Time | 60s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | | | | | | | | | | | |
| 20 | 70 | 70 | 217 | 60 | 16069 | 47089 | 4610 | 0.0007 | 0.359 | 33.67 | 12.09 | 37.152 |
| 30 | 87 | 87 | 258 | 90 | 22670 | 66564 | 8050 | 0.0006 | 0.400 | 33.00 | 13.22 | 39.431 |
| 40 | 101 | 101 | 317 | 120 | 34411 | 100489 | 13100 | 0.0005 | 0.431 | 30.46 | 13.14 | 46.667 |
| 50 | 129 | 129 | 408 | 150 | 58526 | 166464 | 21170 | 0.0003 | 0.488 | 27.92 | 13.62 | 62.813 |
| 60 | 178 | 178 | 515 | 180 | 91589 | 265225 | 31690 | 0.0002 | 0.573 | 25.63 | 14.68 | 63.452 |
| 70 | 208 | 208 | 635 | 210 | 136949 | 403225 | 45160 | 0.0003 | 0.619 | 23.57 | 14.60 | 59.820 |
| 80 | 249 | 249 | 770 | 240 | 203234 | 592900 | 62650 | 0.0002 | 0.677 | 21.51 | 14.58 | 73.034 |
| 90 | 313 | 313 | 943 | 270 | 305131 | 889249 | 86190 | 0.0002 | 0.760 | 19.28 | 14.65 | 81.253 |
| 100 | 381 | 381 | 1135 | 300 | 437611 | 1288225 | 114780 | 0.0002 | 0.838 | 17.05 | 14.29 | 80.052 |
| 110 | 441 | 441 | 1398 | 330 | 671418 | 1954404 | 155730 | 0.0001 | 0.902 | 15.14 | 13.65 | 101.147 |
| 120 | 576 | 576 | | | | | | | 1.000 | 13.54 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/MDF full preheat, test 1** | Ignition Time | 550 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | 564 | 14 | | | | | | | 1.000 | 24.80 | | |
| 70 | 579 | 29 | 1768 | 210 | 1043962 | 3125824 | 124370 | 0.0003 | 1.000 | 22.75 | 22.75 | 57.555 |
| 80 | 625 | 75 | 1864 | 240 | 1161466 | 3474496 | 149930 | 0.0002 | 1.000 | 20.62 | 20.62 | 63.835 |
| 90 | 660 | 110 | 2193 | 270 | 1650689 | 4809249 | 200200 | 0.0001 | 1.000 | 18.39 | 18.39 | 129.699 |
| 100 | 908 | 358 | | | | | | | 1.000 | 16.28 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/MDF full preheat, test 2** | Ignition Time | 571 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | 0 | 0 | | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | | |
| 70 | 579 | 8 | | | | | | | 1.000 | 22.75 | | |
| 80 | 592 | 21 | 1776 | 240 | 1051730 | 3154176 | 142340 | 0.00077 | 1.000 | 20.62 | 20.62 | 36.056 |
| 90 | 605 | 34 | 1851 | 270 | 1144205 | 3426201 | 167210 | 0.00029 | 1.000 | 18.39 | 18.39 | 58.723 |
| 100 | 654 | 83 | 2006 | 300 | 1351750 | 4024036 | 202020 | 0.00014 | 1.000 | 16.28 | 16.28 | 85.599 |
| 110 | 747 | 176 | 2268 | 330 | 1737414 | 5143824 | 251610 | 0.00009 | 1.000 | 14.50 | 14.50 | 103.475 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 867 | 296 | 2539 | 360 | 2165323 | 6446521 | 306460 | 0.00011 | 1.000 | 12.91 | 12.91 | 96.229 |
| 130 | 925 | 354 | 2820 | 385 | 2664098 | 7952400 | 363070 | 0.00009 | 1.000 | 11.48 | 11.48 | 106.611 |
| 135 | 1028 | 457 | | | | | | | 1.000 | 11.72 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/MDF full preheat, test 3** | Ignition Time | 557 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 0 | 0 | | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | | | | |
| 80 | 566 | 9 | | | | | | | 1.000 | 20.62 | | |
| 90 | 610 | 53 | 1824 | 270 | 1112360 | 3326976 | 164980 | 0.0002 | 1.000 | 18.39 | 18.39 | 64.088 |
| 100 | 648 | 91 | 1983 | 300 | 1317629 | 3932289 | 199450 | 0.0002 | 1.000 | 16.28 | 16.28 | 77.269 |
| 110 | 725 | 168 | 2255 | 330 | 1723453 | 5085025 | 250390 | 0.0001 | 1.000 | 14.50 | 14.50 | 110.254 |
| 120 | 882 | 325 | 2604 | 357 | 2297558 | 6780816 | 312209 | 0.0001 | 1.000 | 12.91 | 12.91 | 126.420 |
| 127 | 997 | 440 | | | | | | | 1.000 | 13.10 | 13.10 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/MDF full preheat, test 4** | Ignition Time | 549 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 0 | 0 | | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 0 | 0 | | | | | | | | | | |
| 70 | 555 | 6 | | | | | | | 1.000 | 23.57 | | |
| 80 | 559 | 10 | 1720 | 240 | 987742 | 2958400 | 138110 | 0.0003 | 1.000 | 21.51 | 21.51 | 56.163 |
| 90 | 606 | 57 | 1849 | 270 | 1147573 | 3418801 | 167660 | 0.0002 | 1.000 | 19.28 | 19.28 | 79.863 |
| 100 | 684 | 135 | 2138 | 300 | 1554196 | 4571044 | 216220 | 0.0001 | 1.000 | 17.05 | 17.05 | 112.291 |
| 110 | 848 | 299 | 2467 | 330 | 2061185 | 6086089 | 273880 | 0.0001 | 1.000 | 15.14 | 15.14 | 113.770 |
| 120 | 935 | 386 | | | | | | | 1.000 | 13.54 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_e$* | *$\dot{q}''_e . F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RIFT – Melteca/MDF full preheat, test 5 | Ignition Time | 565 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 0 | 0 | | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | | | | |
| 80 | 571 | 6 | | | | | | | 1.000 | 21.51 | | |
| 90 | 579 | 14 | 1767 | 270 | 1041971 | 3122289 | 159490 | 0.0004 | 1.000 | 19.28 | 19.28 | 51.245 |
| 100 | 617 | 52 | 2036 | 300 | 1421530 | 4145296 | 206210 | 0.0001 | 1.000 | 17.05 | 17.05 | 123.432 |
| 110 | 840 | 275 | | | | | | | 1.000 | 15.14 | | |

**Melteca/ particle board**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Melteca/PB low preheat ISO ign data RIFT - Test 1 | Ignition Time | 60 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | 0.332 | 34.25 | 11.38 | |
| 20 | 66 | 6 | 204 | 60 | 14040 | 41616 | 4260 | 0.0011 | 0.349 | 33.40 | 11.64 | 30.551 |
| 30 | 78 | 18 | 233 | 90 | 18361 | 54289 | 7220 | 0.0009 | 0.379 | 31.99 | 12.12 | 33.922 |
| 40 | 89 | 29 | 289 | 120 | 28889 | 83521 | 12000 | 0.0004 | 0.405 | 29.45 | 11.92 | 48.819 |
| 50 | 122 | 62 | 368 | 150 | 47454 | 135424 | 19080 | 0.0003 | 0.474 | 27.00 | 12.80 | 58.318 |
| 60 | 157 | 97 | 477 | 180 | 78737 | 227529 | 29380 | 0.0003 | 0.538 | 24.80 | 13.33 | 61.708 |
| 70 | 198 | 138 | 585 | 210 | 116753 | 342225 | 41680 | 0.0003 | 0.604 | 22.75 | 13.73 | 60.568 |
| 80 | 230 | 170 | 693 | 240 | 162329 | 480249 | 56110 | 0.0003 | 0.651 | 20.62 | 13.42 | 57.899 |
| 90 | 265 | 205 | 895 | 270 | 283125 | 801025 | 82250 | 0.0001 | 0.698 | 18.39 | 12.84 | 97.367 |
| 100 | 400 | 340 | 1121 | 300 | 438161 | 1256641 | 114010 | 0.0001 | 0.858 | 16.28 | 13.97 | 100.472 |
| 110 | 456 | 396 | 1355 | 330 | 616937 | 1836025 | 150040 | 0.0002 | 0.916 | 14.50 | 13.28 | 70.558 |
| 120 | 499 | 439 | 1513 | 360 | 768301 | 2289169 | 182580 | 0.0002 | 0.958 | 12.91 | 12.37 | 71.707 |
| 130 | 558 | 498 | | | | | | | 1.000 | 11.48 | 11.48 | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Melteca/PB low preheat ISO ign data RIFT - Test 2 | Ignition Time | 60 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | 0.332 | 34.25 | 11.38 | |
| 20 | 69 | 9 | 204 | 60 | 13986 | 41616 | 4230 | 0.00132 | 0.356 | 33.40 | 11.90 | 27.568 |
| 30 | 75 | 15 | 231 | 90 | 17955 | 53361 | 7110 | 0.00107 | 0.372 | 31.99 | 11.88 | 30.551 |
| 40 | 87 | 27 | 272 | 120 | 25294 | 73984 | 11230 | 0.00055 | 0.400 | 29.45 | 11.78 | 42.516 |
| 50 | 110 | 50 | 341 | 150 | 40405 | 116281 | 17620 | 0.00035 | 0.450 | 27.00 | 12.15 | 53.716 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 144 | 84 | 426 | 180 | 62420 | 181476 | 26180 | 0.00032 | 0.515 | 24.80 | 12.77 | 55.764 |
| 70 | 172 | 112 | 523 | 210 | 93169 | 273529 | 37240 | 0.00032 | 0.563 | 22.75 | 12.80 | 56.240 |
| 80 | 207 | 147 | 643 | 240 | 142129 | 413449 | 52360 | 0.00021 | 0.617 | 20.62 | 12.73 | 68.467 |
| 90 | 264 | 204 | 825 | 270 | 237861 | 680625 | 75720 | 0.00013 | 0.697 | 18.39 | 12.82 | 86.449 |
| 100 | 354 | 294 | 1078 | 300 | 406612 | 1162084 | 109760 | 0.00010 | 0.807 | 16.28 | 13.14 | 99.105 |
| 110 | 460 | 400 | 1337 | 330 | 610445 | 1787569 | 148760 | 0.00012 | 0.920 | 14.50 | 13.34 | 92.910 |
| 120 | 523 | 463 | 1602 | 355 | 868290 | 2566404 | 190735 | 0.00009 | 0.981 | 12.91 | 12.66 | 104.910 |
| 125 | 619 | 559 | | | | | | | | 13.22 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Melteca/PB low preheat ISO ign data RIFT - Test 3 | Ignition Time | 60 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | | | | |
| 20 | 76 | 16 | 223 | 60 | 16945 | 49729 | 4730 | 0.0007 | 0.374 | 33.40 | 12.49 | 36.952 |
| 30 | 87 | 27 | 270 | 90 | 24794 | 72900 | 8410 | 0.0006 | 0.400 | 31.99 | 12.80 | 39.919 |
| 40 | 107 | 47 | 323 | 120 | 35659 | 104329 | 13340 | 0.0005 | 0.444 | 29.45 | 13.07 | 45.843 |
| 50 | 129 | 69 | 400 | 150 | 54986 | 160000 | 20570 | 0.0003 | 0.487 | 27.00 | 13.16 | 53.846 |
| 60 | 164 | 104 | 480 | 180 | 78506 | 230400 | 29380 | 0.0003 | 0.549 | 24.80 | 13.63 | 54.234 |
| 70 | 187 | 127 | 591 | 210 | 119465 | 349281 | 42130 | 0.0003 | 0.587 | 22.75 | 13.35 | 63.225 |
| 80 | 240 | 180 | 723 | 240 | 180185 | 522729 | 58930 | 0.0002 | 0.665 | 20.62 | 13.71 | 73.833 |
| 90 | 296 | 236 | 887 | 270 | 268417 | 786769 | 80940 | 0.0002 | 0.738 | 18.39 | 13.57 | 74.499 |
| 100 | 351 | 291 | 1116 | 300 | 430778 | 1245456 | 113330 | 0.0001 | 0.804 | 16.28 | 13.09 | 95.039 |
| 110 | 469 | 409 | 1349 | 330 | 623003 | 1819801 | 150170 | 0.0001 | 0.929 | 14.50 | 13.47 | 95.995 |
| 120 | 529 | 469 | 1642 | 360 | 914538 | 2696164 | 198790 | 0.0001 | 0.987 | 12.91 | 12.73 | 95.069 |
| 130 | 644 | 584 | 1854 | 381 | 1158338 | 3437316 | 236411 | 0.0001 | 1.000 | 11.48 | 11.48 | 114.829 |
| 131 | 681 | 621 | | | | | | | | 11.90 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Melteca/PB low preheat ISO ign data RIFT - Test 4** | Ignition Time | 63 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 63 | 0 | 145 | 30 | 10693 | 21025 | 2270 | 0.0002 | 0.341 | 34.64 | 11.80 | 67.034 |
| 20 | 82 | 19 | 236 | 60 | 18974 | 55696 | 5000 | 0.0007 | 0.388 | 33.67 | 13.08 | 38.204 |
| 30 | 91 | 28 | 279 | 90 | 26241 | 77841 | 8610 | 0.0008 | 0.409 | 33.00 | 13.51 | 35.000 |
| 40 | 106 | 43 | 319 | 120 | 34401 | 101761 | 13070 | 0.0006 | 0.442 | 30.46 | 13.46 | 39.377 |
| 50 | 122 | 59 | 373 | 150 | 47145 | 139129 | 19040 | 0.0005 | 0.474 | 27.92 | 13.23 | 44.395 |
| 60 | 145 | 82 | 433 | 180 | 63465 | 187489 | 26420 | 0.0005 | 0.517 | 25.63 | 13.24 | 46.920 |
| 70 | 166 | 103 | 513 | 210 | 89385 | 263169 | 36480 | 0.0003 | 0.553 | 23.57 | 13.03 | 53.998 |
| 80 | 202 | 139 | 640 | 240 | 142344 | 409600 | 52260 | 0.0002 | 0.610 | 21.51 | 13.12 | 74.039 |
| 90 | 272 | 209 | 793 | 270 | 216549 | 628849 | 72540 | 0.0002 | 0.708 | 19.28 | 13.64 | 76.976 |
| 100 | 319 | 256 | 959 | 300 | 311169 | 919681 | 96860 | 0.0002 | 0.766 | 17.05 | 13.06 | 69.287 |
| 110 | 368 | 305 | 1127 | 330 | 430785 | 1270129 | 125180 | 0.0002 | 0.823 | 15.14 | 12.46 | 78.249 |
| 120 | 440 | 377 | 1369 | 360 | 643745 | 1874161 | 166210 | 0.0001 | 0.900 | 13.54 | 12.19 | 99.284 |
| 130 | 561 | 498 | 1640 | 390 | 916642 | 2689600 | 215190 | 0.0001 | 1.000 | 11.95 | 11.95 | 100.523 |
| 140 | 639 | 576 | 1916 | 415 | 1235698 | 3671056 | 266210 | 0.0001 | 1.000 | 10.78 | 10.78 | 101.617 |
| 145 | 716 | 653 | | | | | | | | 10.78 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Melteca/PB low preheat ISO ign data RIFT - Test 5** | Ignition Time | 60 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | | | | |
| 20 | 81 | 21 | 245 | 60 | 20977 | 60025 | 5340 | 0.0005 | 0.386 | 33.67 | 13.00 | 46.920 |
| 30 | 104 | 44 | 297 | 90 | 29921 | 88209 | 9220 | 0.0006 | 0.437 | 33.00 | 14.44 | 40.877 |
| 40 | 112 | 52 | 344 | 120 | 39744 | 118336 | 14000 | 0.0008 | 0.454 | 30.46 | 13.83 | 35.277 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 128 | 68 | 414 | 150 | 59204 | 171396 | 21320 | 0.0003 | 0.485 | 27.92 | 13.55 | 57.809 |
| 60 | 174 | 114 | 496 | 180 | 84296 | 246016 | 30420 | 0.0003 | 0.566 | 25.63 | 14.50 | 58.913 |
| 70 | 194 | 134 | 582 | 210 | 113708 | 338724 | 41140 | 0.0005 | 0.598 | 23.57 | 14.08 | 44.721 |
| 80 | 214 | 154 | 654 | 240 | 143948 | 427716 | 52840 | 0.0004 | 0.628 | 21.51 | 13.50 | 51.441 |
| 90 | 246 | 186 | 752 | 270 | 191576 | 565504 | 68460 | 0.0003 | 0.673 | 19.28 | 12.97 | 62.784 |
| 100 | 292 | 232 | 892 | 300 | 271096 | 795664 | 90280 | 0.0002 | 0.733 | 17.05 | 12.50 | 73.753 |
| 110 | 354 | 294 | 1075 | 330 | 394621 | 1155625 | 119620 | 0.0001 | 0.807 | 15.14 | 12.22 | 82.889 |
| 120 | 429 | 369 | 1365 | 358 | 648081 | 1863225 | 164916 | 0.0001 | 0.889 | 13.54 | 12.03 | 115.454 |
| 128 | 582 | 522 | | | | | | | | 13.54 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Melteca/PB low preheat ISO ign data RIFT - Test 6** | Ignition Time | 60s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | | | | | | | | | | | |
| 20 | 79 | 79 | 228 | 60 | 17762 | 51984 | 4850 | 0.0007 | 0.381 | 33.67 | 12.84 | 38.685 |
| 30 | 89 | 89 | 269 | 90 | 24363 | 72361 | 8290 | 0.0009 | 0.405 | 33.00 | 13.36 | 33.212 |
| 40 | 101 | 101 | 318 | 120 | 34506 | 101124 | 13110 | 0.0005 | 0.431 | 30.46 | 13.13 | 45.234 |
| 50 | 128 | 128 | 419 | 150 | 62685 | 175561 | 21840 | 0.0002 | 0.485 | 27.92 | 13.55 | 68.406 |
| 60 | 190 | 190 | 536 | 180 | 100008 | 287296 | 33060 | 0.0002 | 0.591 | 25.63 | 15.15 | 68.659 |
| 70 | 218 | 218 | 667 | 210 | 150705 | 444889 | 47380 | 0.0003 | 0.633 | 23.57 | 14.93 | 59.083 |
| 80 | 259 | 259 | 793 | 240 | 214461 | 628849 | 64420 | 0.0002 | 0.690 | 21.51 | 14.85 | 70.310 |
| 90 | 316 | 316 | 945 | 270 | 303837 | 893025 | 86160 | 0.0002 | 0.763 | 19.28 | 14.70 | 74.507 |
| 100 | 370 | 370 | 1107 | 300 | 413997 | 1225449 | 111750 | 0.0002 | 0.825 | 17.05 | 14.07 | 72.467 |
| 110 | 421 | 421 | 1364 | 330 | 642470 | 1860496 | 152070 | 0.0001 | 0.880 | 15.14 | 13.32 | 104.821 |
| 120 | 573 | 573 | | | | | | | | 13.54 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/part bd – full preheat – test 1** | Ignition Time | 550s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | 567 | 17 | | | | | | | 1.000 | 24.80 | | |
| 70 | 577 | 27 | 1732 | 210 | 1000162 | 2999824 | 121450 | 0.0010 | 1.000 | 22.75 | 22.75 | 32.416 |
| 80 | 588 | 38 | 1839 | 240 | 1132949 | 3381921 | 148090 | 0.0002 | 1.000 | 20.62 | 20.62 | 76.266 |
| 90 | 674 | 124 | 1969 | 270 | 1299869 | 3876961 | 178400 | 0.0002 | 1.000 | 18.39 | 18.39 | 79.646 |
| 100 | 707 | 157 | 2129 | 300 | 1513629 | 4532641 | 213640 | 0.0003 | 1.000 | 16.28 | 16.28 | 60.946 |
| 110 | 748 | 198 | 2307 | 330 | 1785257 | 5322249 | 255220 | 0.0001 | 1.000 | 14.50 | 14.50 | 87.785 |
| 120 | 852 | 302 | 2508 | 355 | 2109872 | 6290064 | 298020 | 0.0001 | 1.000 | 12.91 | 12.91 | 103.113 |
| 125 | 908 | 358 | | | | | | | | 13.22 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/part bd – full preheat – test 2** | Ignition Time | 542 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 0 | 0 | | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | 0.000 | 22.75 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 560 | 18 | 1146 | 240 | 656996 | 1313316 | 97540 | 0.00003 | 1.000 | 20.62 | 20.62 | 193.417 |
| 90 | 586 | 44 | 1764 | 270 | 1038920 | 3111696 | 159340 | 0.00034 | 1.000 | 18.39 | 18.39 | 53.948 |
| 100 | 618 | 76 | 1862 | 300 | 1158284 | 3467044 | 186920 | 0.00028 | 1.000 | 16.28 | 16.28 | 60.123 |
| 110 | 658 | 116 | 2014 | 330 | 1359532 | 4056196 | 222740 | 0.00016 | 1.000 | 14.50 | 14.50 | 78.881 |
| 120 | 738 | 196 | 2198 | 360 | 1620812 | 4831204 | 265200 | 0.00014 | 1.000 | 12.91 | 12.91 | 85.027 |
| 130 | 802 | 260 | 2423 | 385 | 1967537 | 5870929 | 312025 | 0.00010 | 1.000 | 11.48 | 11.48 | 99.192 |
| 135 | 883 | 341 | | | | | | | | 11.72 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/part bd – full preheat – test 3** | Ignition Time | 545 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | 0.000 | 20.62 | | |
| 90 | 572 | 27 | 1182 | 270 | 699284 | 1397124 | 112480 | 0.0000 | 1.000 | 18.39 | 18.39 | 195.681 |
| 100 | 610 | 65 | 1947 | 300 | 1284509 | 3790809 | 196630 | 0.0001 | 1.000 | 16.28 | 16.28 | 104.077 |
| 110 | 765 | 220 | 2239 | 330 | 1703821 | 5013121 | 248830 | 0.0001 | 1.000 | 14.50 | 14.50 | 113.604 |
| 120 | 864 | 319 | 2577 | 360 | 2230425 | 6640929 | 311070 | 0.0001 | 1.000 | 12.91 | 12.91 | 95.763 |
| 130 | 948 | 403 | 2841 | 389 | 2704041 | 8071281 | 369951 | 0.0001 | 1.000 | 11.48 | 11.48 | 93.179 |
| 139 | 1029 | 484 | | | | | | | 1.000 | 11.53 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_e$* | *$\dot{q}''_e . F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/part bd – full preheat – test 4** | Ignition Time | 545 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | 559 | 14 | | | | | | | 1.000 | 21.51 | | |
| 90 | 583 | 38 | 1743 | 270 | 1013571 | 3038049 | 157290 | 0.0005 | 1.000 | 19.28 | 19.28 | 45.981 |
| 100 | 601 | 56 | 1863 | 300 | 1162131 | 3470769 | 187260 | 0.0002 | 1.000 | 17.05 | 17.05 | 73.655 |
| 110 | 679 | 134 | 2084 | 330 | 1468658 | 4343056 | 231270 | 0.0001 | 1.000 | 15.14 | 15.14 | 101.643 |
| 120 | 804 | 259 | 2371 | 360 | 1896001 | 5621641 | 286610 | 0.0001 | 1.000 | 13.54 | 13.54 | 102.879 |
| 130 | 888 | 343 | 2694 | 383 | 2438964 | 7257636 | 345186 | 0.0001 | 1.000 | 11.95 | 11.95 | 125.604 |
| 133 | 1002 | 457 | | | | | | | 1.000 | 11.95 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_e$* | *$\dot{q}''_e . F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/part bd – full preheat – test 5** | Ignition Time | 613 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | 625 | 12 | | | | | | | 1.000 | 21.51 | | |
| 90 | 639 | 26 | 1921 | 270 | 1230595 | 3690241 | 173210 | 0.0006 | 1.000 | 19.28 | 19.28 | 40.104 |
| 100 | 657 | 44 | 1991 | 300 | 1322995 | 3964081 | 199660 | 0.0003 | 1.000 | 17.05 | 17.05 | 54.028 |
| 110 | 695 | 82 | 2088 | 330 | 1456370 | 4359744 | 230470 | 0.0003 | 1.000 | 15.14 | 15.14 | 62.864 |
| 120 | 736 | 123 | 2213 | 360 | 1636245 | 4897369 | 266430 | 0.0002 | 1.000 | 13.54 | 13.54 | 65.991 |
| 130 | 782 | 169 | 2390 | 385 | 1913604 | 5712100 | 307700 | 0.0001 | 1.000 | 11.95 | 11.95 | 98.655 |
| 135 | 872 | 259 | | | | | | | 1.000 | 11.95 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *Time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Melteca/part bd – full preheat – test 6** | Ignition Time | 543 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | 551 | 8 | | | | | | | 1.000 | 23.57 | | |
| 80 | 576 | 33 | 1728 | 240 | 996578 | 2985984 | 138740 | 0.0004 | 1.000 | 21.51 | 21.51 | 50.000 |
| 90 | 601 | 58 | 1821 | 270 | 1107713 | 3316041 | 164570 | 0.0003 | 1.000 | 19.28 | 19.28 | 58.987 |
| 100 | 644 | 101 | 1912 | 300 | 1220826 | 3655744 | 191860 | 0.0003 | 1.000 | 17.05 | 17.05 | 58.318 |
| 110 | 667 | 124 | 2002 | 330 | 1337106 | 4008004 | 220690 | 0.0004 | 1.000 | 15.14 | 15.14 | 48.480 |
| 120 | 691 | 148 | 2061 | 360 | 1416579 | 4247721 | 247680 | 0.0005 | 1.000 | 13.54 | 13.54 | 43.205 |
| 130 | 703 | 160 | 2141 | 390 | 1529699 | 4583881 | 278890 | 0.0003 | 1.000 | 11.95 | 11.95 | 55.720 |
| 140 | 747 | 204 | 2285 | 420 | 1749443 | 5221225 | 321220 | 0.0001 | 1.000 | 10.78 | 10.78 | 82.731 |
| 150 | 835 | 292 | 2507 | 447 | 2110859 | 6285049 | 375055 | 0.0001 | 1.000 | 9.61 | 9.61 | 102.362 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 157 | | 925 | 382 | | | | | | | | 9.02 | | |

**Hardboard**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Hardboard – test 1** | Ignition Time | 606 | | | | | | m/s | mm/s | kW/m² | | (m/s)$^{-0.5}$ | |
| 50 | 0 | 0 | | | | | | | | | | | |
| 75 | 0 | 0 | | | | | | | | | 22.05 | | |
| 100 | 0 | 0 | | | | | | | | | 21.94 | | |
| 125 | 0 | 0 | | | | | | | | | 21.10 | | |
| 150 | 0 | 0 | | | | | | | | | 20.27 | | |
| 175 | 0 | 0 | | | | | | | | | 19.66 | | |
| 200 | 0 | 0 | | | | | | | | | 19.05 | | |
| 225 | 0 | 0 | | | | | | | | | 18.25 | | |
| 250 | 612 | 6 | | | | | | | | 1.000 | 17.45 | 17.45 | |
| 275 | 626 | 20 | 1878 | 825 | 1176020 | 3526884 | 517150 | 0.0018 | 1.7857 | 1.000 | 15.86 | 15.86 | 23.664 |
| 300 | 640 | 34 | 1933 | 900 | 1246365 | 3736489 | 580925 | 0.0012 | 1.1800 | 1.000 | 14.28 | 14.28 | 29.112 |
| 325 | 667 | 61 | 2021 | 975 | 1364285 | 4084441 | 658675 | 0.0007 | 0.6596 | 1.000 | 12.89 | 12.89 | 38.936 |
| 350 | 714 | 108 | 2155 | 1050 | 1553761 | 4644025 | 756925 | 0.0005 | 0.4650 | 1.000 | 11.50 | 11.50 | 46.374 |
| 375 | 774 | 168 | 2325 | 1125 | 1809441 | 5405625 | 874950 | 0.0004 | 0.4064 | 1.000 | 10.17 | 10.17 | 49.603 |
| 400 | 837 | 231 | 2542 | 1200 | 2166406 | 6461764 | 1020725 | 0.0003 | 0.3144 | 1.000 | 8.83 | 8.83 | 56.399 |
| 425 | 931 | 325 | 2834 | 1275 | 2703686 | 8031556 | 1210175 | 0.0002 | 0.2160 | 1.000 | 7.59 | 7.59 | 68.036 |
| 450 | 1066 | 460 | 3223 | 1350 | 3506193 | 10387729 | 1457725 | 0.0002 | 0.1691 | 1.000 | 6.35 | 6.35 | 76.903 |
| 475 | 1226 | 620 | 3726 | 1425 | 4695788 | 13883076 | 1779050 | 0.0001 | 0.1351 | 1.000 | 5.42 | 5.42 | 86.033 |
| 500 | 1434 | 828 | 4359 | 1500 | 6446033 | 19000881 | 2191325 | 0.0001 | 0.1052 | 1.000 | 4.50 | 4.50 | 97.498 |
| 525 | 1699 | 1093 | | | | | | | | 1.000 | 3.79 | 3.79 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Hardboard** | Ignition | 608 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ | |

| – test 2 | Time | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 0 | 0 | | | | | | | | | | | | |
| 75 | 0 | 0 | | | | | | | | | 22.05 | | | |
| 100 | 0 | 0 | | | | | | | | | 21.94 | | | |
| 125 | 0 | 0 | | | | | | | | | 21.10 | | | |
| 150 | 0 | 0 | | | | | | | | | 20.27 | | | |
| 175 | 0 | 0 | | | | | | | | | 19.66 | | | |
| 200 | 0 | 0 | | | | | | | | | 19.05 | | | |
| 225 | 0 | 0 | | | | | | | | | 18.25 | | | |
| 250 | 0 | 0 | | | | | | | | | 17.45 | | | |
| 275 | 617 | 11 | | | | | | | | 1.000 | 15.86 | 15.86 | | |
| 300 | 626 | 20 | 1887 | 900 | 1187301 | 3560769 | 566775 | 0.0018 | 1.7857 | 1.000 | 14.28 | 14.28 | 23.664 | |
| 325 | 644 | 38 | 1936 | 975 | 1250168 | 3748096 | 630200 | 0.0012 | 1.2458 | 1.000 | 12.89 | 12.89 | 28.331 | |
| 350 | 666 | 60 | 2010 | 1050 | 1348292 | 4040100 | 704900 | 0.0009 | 0.8794 | 1.000 | 11.50 | 11.50 | 33.722 | |
| 375 | 700 | 94 | 2117 | 1125 | 1497557 | 4481689 | 796000 | 0.0006 | 0.5805 | 1.000 | 10.17 | 10.17 | 41.505 | |
| 400 | 751 | 145 | 2265 | 1200 | 1716597 | 5130225 | 908850 | 0.0004 | 0.4370 | 1.000 | 8.83 | 8.83 | 47.837 | |
| 425 | 814 | 208 | 2472 | 1275 | 2049246 | 6110784 | 1054500 | 0.0003 | 0.3166 | 1.000 | 7.59 | 7.59 | 56.200 | |
| 450 | 907 | 301 | 1721 | 925 | 1485245 | 2961841 | 754100 | 0.0004 | 0.4487 | 1.000 | 6.35 | 6.35 | 47.206 | |
| 475 | 1015 | 409 | 1922 | 1000 | 1852874 | 3694084 | 890275 | 0.0004 | 0.4016 | 1.000 | 5.42 | 5.42 | 49.899 | |
| 500 | 1111 | 505 | 2126 | 1075 | 2264546 | 4519876 | 1037625 | 0.0004 | 0.3639 | 1.000 | 4.50 | 4.50 | 52.421 | |
| 525 | 1369 | 763 | 2480 | 1150 | 3108482 | 6150400 | 1274225 | 0.0003 | 0.3057 | 1.000 | 3.79 | 3.79 | 57.192 | |
| 550 | 1597 | 991 | 2966 | 1225 | 4424570 | 8797156 | 1597075 | 0.0003 | 0.2587 | 1.000 | 3.08 | 3.08 | 62.179 | |
| 558 | 1665 | 1059 | | | | | | | | | 2.96 | | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Hardboard – test 3** | Ignition Time | 610 | | | | | | m/s | mm/s | | kW/m² | | |
| 50 | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 125 | | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | | |
| 225 | | | | | | | | | | | | | |
| 250 | | | | | | | | | | | | | |
| 275 | 617 | 11 | | | | | | | | 1.000 | 15.86 | 15.86 | |
| 300 | 622 | 16 | 1877 | 900 | 1174617 | 3523129 | 563625 | 0.0022 | 2.1814 | 1.000 | 14.28 | 14.28 | 21.411 |
| 325 | 638 | 32 | 1923 | 975 | 1233497 | 3697929 | 626000 | 0.0012 | 1.2002 | 1.000 | 12.89 | 12.89 | 28.865 |
| 350 | 663 | 57 | 1997 | 1050 | 1331029 | 3988009 | 700400 | 0.0009 | 0.8566 | 1.000 | 11.50 | 11.50 | 34.167 |
| 375 | 696 | 90 | 2099 | 1125 | 1471585 | 4405801 | 789050 | 0.0006 | 0.6450 | 1.000 | 10.17 | 10.17 | 39.376 |
| 400 | 740 | 134 | 2238 | 1200 | 1675220 | 5008644 | 897850 | 0.0005 | 0.4672 | 1.000 | 8.83 | 8.83 | 46.264 |
| 425 | 802 | 196 | 2422 | 1275 | 1965204 | 5866084 | 1032850 | 0.0004 | 0.3556 | 1.000 | 7.59 | 7.59 | 53.030 |
| 450 | 880 | 274 | 2666 | 1350 | 2385860 | 7107556 | 1204250 | 0.0003 | 0.2729 | 1.000 | 6.35 | 6.35 | 60.537 |
| 475 | 984 | 378 | 3012 | 1425 | 3060560 | 9072144 | 1437400 | 0.0002 | 0.1835 | 1.000 | 5.42 | 5.42 | 73.821 |
| 500 | 1148 | 542 | 3514 | 1500 | 4196084 | 12348196 | 1766950 | 0.0001 | 0.1243 | 1.000 | 4.50 | 4.50 | 89.678 |
| 525 | 1382 | 776 | 4082 | 1565 | 5636532 | 16662724 | 2137630 | 0.0001 | 0.0995 | 1.000 | 3.79 | 3.79 | 100.259 |
| 540 | 1552 | 946 | | | | | | | | 1.000 | 3.36 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Hardboard – low preheat – ISO ign data – test 1** | Ignition Time | 80 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 80 | 0 | | | | | | | 0.291 | 33.88 | | |
| 20 | 83 | 3 | 250 | 60 | 20858 | 62500 | 5070 | 0.0028 | 0.296 | 32.87 | 9.75 | 18.772 |
| 30 | 87 | 7 | 259 | 90 | 22379 | 67081 | 7830 | 0.0032 | 0.304 | 32.16 | 9.76 | 17.638 |
| 40 | 89 | 9 | 272 | 120 | 24706 | 73984 | 10970 | 0.0020 | 0.307 | 29.67 | 9.11 | 22.278 |
| 50 | 96 | 16 | 292 | 150 | 28586 | 85264 | 14780 | 0.0011 | 0.319 | 27.17 | 8.66 | 30.246 |
| 60 | 107 | 27 | 321 | 180 | 34589 | 103041 | 19480 | 0.0009 | 0.337 | 24.95 | 8.40 | 33.166 |
| 70 | 118 | 38 | 359 | 210 | 43329 | 128881 | 25400 | 0.0007 | 0.354 | 22.99 | 8.13 | 36.952 |
| 80 | 134 | 54 | 405 | 240 | 55289 | 164025 | 32750 | 0.0006 | 0.377 | 21.03 | 7.92 | 41.884 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | 153 | 73 | 459 | 270 | 70949 | 210681 | 41690 | 0.0005 | 0.403 | 18.88 | 7.60 | 43.589 |
| 100 | 172 | 92 | 525 | 300 | 92993 | 275625 | 52970 | 0.0004 | 0.427 | 16.73 | 7.14 | 48.772 |
| 110 | 200 | 120 | 602 | 330 | 122484 | 362404 | 66800 | 0.0003 | 0.460 | 15.06 | 6.93 | 53.862 |
| 120 | 230 | 150 | 699 | 360 | 165261 | 488601 | 84570 | 0.0003 | 0.494 | 13.89 | 6.85 | 58.903 |
| 130 | 269 | 189 | 803 | 390 | 217677 | 644809 | 105130 | 0.0003 | 0.534 | 12.71 | 6.78 | 60.857 |
| 140 | 304 | 224 | 922 | 420 | 286578 | 850084 | 129880 | 0.0002 | 0.567 | 11.59 | 6.58 | 63.410 |
| 150 | 349 | 269 | 1054 | 450 | 375018 | 1110916 | 159070 | 0.0002 | 0.608 | 10.48 | 6.37 | 69.702 |
| 160 | 401 | 321 | 1198 | 480 | 483306 | 1435204 | 192670 | 0.0002 | 0.652 | 9.39 | 6.12 | 70.386 |
| 170 | 448 | 368 | 1360 | 510 | 622626 | 1849600 | 232300 | 0.0002 | 0.689 | 8.33 | 5.74 | 74.423 |
| 180 | 511 | 431 | 1531 | 540 | 789009 | 2343961 | 276820 | 0.0002 | 0.736 | 7.27 | 5.35 | 78.743 |
| 190 | 572 | 492 | 1720 | 570 | 994074 | 2958400 | 328060 | 0.0002 | 0.778 | 6.55 | 5.10 | 79.386 |
| 200 | 637 | 557 | 1915 | 600 | 1231389 | 3667225 | 384340 | 0.0001 | 0.821 | 5.83 | 4.79 | 81.866 |
| 210 | 706 | 626 | 2118 | 630 | 1504830 | 4485924 | 446160 | 0.0001 | 0.865 | 5.17 | 4.47 | 83.066 |
| 220 | 775 | 695 | 2329 | 660 | 1818165 | 5424241 | 513800 | 0.0001 | 0.906 | 4.58 | 4.15 | 84.273 |
| 230 | 848 | 768 | 2557 | 690 | 2192085 | 6538249 | 589700 | 0.0001 | 0.948 | 3.99 | 3.78 | 89.262 |
| 240 | 934 | 854 | 2809 | 720 | 2646189 | 7890481 | 675950 | 0.0001 | 0.995 | 3.77 | 3.75 | 94.629 |
| 250 | 1027 | 947 | 3079 | 750 | 3177009 | 9480241 | 771590 | 0.0001 | 1.000 | 3.54 | 3.54 | 95.919 |
| 260 | 1118 | 1038 | 3341 | 780 | 3735069 | 11162281 | 870350 | 0.0001 | 1.000 | 3.29 | 3.29 | 92.014 |
| 270 | 1196 | 1116 | 3614 | 805 | 4370340 | 13060996 | 971100 | 0.0001 | 1.000 | 3.29 | 3.29 | 111.413 |
| 275 | 1300 | 1220 | | | | | | | 1.000 | 3.09 | 3.09 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Hardboard – low preheat – ISO ign data – test 2** | Ignition Time | 80 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 80 | 0 | | | | | | | 0.291 | 33.88 | | |
| 20 | 82 | 2 | 246 | 60 | 20180 | 60516 | 4960 | 0.0050 | 0.295 | 32.87 | 9.69 | 14.142 |
| 30 | 84 | 4 | 252 | 90 | 21176 | 63504 | 7600 | 0.0050 | 0.298 | 32.16 | 9.59 | 14.142 |
| 40 | 86 | 6 | 262 | 120 | 22916 | 68644 | 10560 | 0.0023 | 0.302 | 29.67 | 8.95 | 20.817 |
| 50 | 92 | 12 | 279 | 150 | 26061 | 77841 | 14100 | 0.0013 | 0.312 | 27.17 | 8.48 | 27.568 |
| 60 | 101 | 21 | 305 | 180 | 31209 | 93025 | 18500 | 0.0010 | 0.327 | 24.95 | 8.16 | 31.675 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 112 | 32 | 342 | 210 | 39386 | 116964 | 24220 | 0.0007 | 0.344 | 22.99 | 7.92 | 37.702 |
| 80 | 129 | 49 | 386 | 240 | 50210 | 148996 | 31210 | 0.0006 | 0.370 | 21.03 | 7.78 | 40.626 |
| 90 | 145 | 65 | 442 | 270 | 65890 | 195364 | 40170 | 0.0005 | 0.392 | 18.88 | 7.40 | 44.395 |
| 100 | 168 | 88 | 509 | 300 | 87665 | 259081 | 51410 | 0.0004 | 0.422 | 16.73 | 7.06 | 50.578 |
| 110 | 196 | 116 | 592 | 330 | 118624 | 350464 | 65720 | 0.0003 | 0.456 | 15.06 | 6.86 | 54.813 |
| 120 | 228 | 148 | 687 | 360 | 159569 | 471969 | 83110 | 0.0003 | 0.491 | 13.89 | 6.82 | 57.899 |
| 130 | 263 | 183 | 798 | 390 | 215402 | 636804 | 104530 | 0.0003 | 0.528 | 12.71 | 6.71 | 62.985 |
| 140 | 307 | 227 | 927 | 420 | 290867 | 859329 | 130720 | 0.0002 | 0.570 | 11.59 | 6.61 | 68.603 |
| 150 | 357 | 277 | 1086 | 450 | 399782 | 1179396 | 164050 | 0.0002 | 0.615 | 10.48 | 6.44 | 76.043 |
| 160 | 422 | 342 | 1263 | 480 | 539789 | 1595169 | 203350 | 0.0002 | 0.669 | 9.39 | 6.28 | 79.694 |
| 170 | 484 | 404 | 986 | 340 | 418740 | 972196 | 150600 | 0.0004 | 0.716 | 8.33 | 5.97 | 49.363 |
| 180 | 555 | 475 | 1121 | 370 | 549005 | 1256641 | 183820 | 0.0004 | 0.767 | 7.27 | 5.58 | 53.441 |
| 190 | 635 | 555 | 1274 | 400 | 718306 | 1623076 | 223070 | 0.0003 | 0.820 | 6.55 | 5.37 | 57.725 |
| 200 | 718 | 638 | 1440 | 430 | 926318 | 2073600 | 267730 | 0.0003 | 0.872 | 5.83 | 5.08 | 61.917 |
| 210 | 812 | 732 | 1619 | 460 | 1182789 | 2621161 | 318570 | 0.0002 | 0.927 | 5.17 | 4.80 | 66.295 |
| 226 | 911 | 831 | | | | | | | 0.982 | 4.23 | 4.15 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Hardboard – low preheat – ISO ign data – test 3** | Ignition Time | 69 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 80 | 0 | | | | | | | 0.291 | 33.88 | | |
| 20 | 82 | 2 | 246 | 60 | 20180 | 60516 | 4960 | 0.0050 | 0.295 | 32.87 | 9.69 | 14.142 |
| 30 | 84 | 4 | 253 | 90 | 21349 | 64009 | 7640 | 0.0039 | 0.298 | 32.16 | 9.59 | 15.916 |
| 40 | 87 | 7 | 260 | 120 | 22546 | 67600 | 10450 | 0.0039 | 0.304 | 29.67 | 9.01 | 15.916 |
| 50 | 89 | 9 | 275 | 150 | 25291 | 75625 | 13870 | 0.0015 | 0.307 | 27.17 | 8.34 | 26.247 |
| 60 | 99 | 19 | 299 | 180 | 30043 | 89401 | 18160 | 0.0009 | 0.324 | 24.95 | 8.08 | 33.212 |
| 70 | 111 | 31 | 339 | 210 | 38763 | 114921 | 24030 | 0.0007 | 0.343 | 22.99 | 7.88 | 38.987 |
| 80 | 129 | 49 | 390 | 240 | 51462 | 152100 | 31590 | 0.0005 | 0.370 | 21.03 | 7.78 | 44.202 |
| 90 | 150 | 70 | 459 | 270 | 71541 | 210681 | 41820 | 0.0004 | 0.399 | 18.88 | 7.53 | 50.759 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 180 | 100 | 533 | 300 | 96109 | 284089 | 53830 | 0.0004 | 0.437 | 16.73 | 7.30 | 51.628 |
| 110 | 203 | 123 | 617 | 330 | 128365 | 380689 | 68410 | 0.0004 | 0.464 | 15.06 | 6.98 | 52.151 |
| 120 | 234 | 154 | 707 | 360 | 168865 | 499849 | 85510 | 0.0003 | 0.498 | 13.89 | 6.91 | 57.933 |
| 130 | 270 | 190 | 818 | 390 | 226252 | 669124 | 107140 | 0.0002 | 0.535 | 12.71 | 6.80 | 63.351 |
| 140 | 314 | 234 | 932 | 420 | 292600 | 868624 | 131260 | 0.0003 | 0.577 | 11.59 | 6.69 | 62.621 |
| 150 | 348 | 268 | 1080 | 450 | 394424 | 1166400 | 163040 | 0.0002 | 0.607 | 10.48 | 6.36 | 73.537 |
| 160 | 418 | 338 | 869 | 370 | 306437 | 755161 | 125260 | 0.0003 | 0.665 | 9.39 | 6.25 | 55.007 |
| 170 | 481 | 401 | 1017 | 400 | 420009 | 1034289 | 156910 | 0.0003 | 0.714 | 8.33 | 5.95 | 59.422 |
| 180 | 554 | 474 | 1170 | 430 | 556502 | 1368900 | 192290 | 0.0002 | 0.766 | 7.27 | 5.57 | 63.835 |
| 190 | 625 | 545 | 1335 | 460 | 721877 | 1782225 | 232510 | 0.0002 | 0.814 | 6.55 | 5.33 | 67.790 |
| 200 | 718 | 638 | 1522 | 490 | 938190 | 2316484 | 280250 | 0.0002 | 0.872 | 5.83 | 5.08 | 72.420 |
| 208 | 828 | 748 | | | | | | | 0.936 | 5.30 | 4.97 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Hardboard – low preheat – ISO ign data – test 4** | Ignition Time | 66 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 80 | 0 | | | | | | | 0.291 | 33.88 | | |
| 20 | 83 | 3 | 248 | 60 | 20514 | 61504 | 5010 | 0.0039 | 0.296 | 32.87 | 9.75 | 15.916 |
| 30 | 85 | 5 | 255 | 90 | 21683 | 65025 | 7690 | 0.0050 | 0.300 | 32.16 | 9.65 | 14.142 |
| 40 | 87 | 7 | 265 | 120 | 23443 | 70225 | 10680 | 0.0023 | 0.304 | 29.67 | 9.01 | 20.817 |
| 50 | 93 | 13 | 283 | 150 | 26827 | 80089 | 14310 | 0.0012 | 0.314 | 27.17 | 8.53 | 28.577 |
| 60 | 103 | 23 | 314 | 180 | 33182 | 98596 | 19090 | 0.0008 | 0.330 | 24.95 | 8.24 | 35.590 |
| 70 | 118 | 38 | 356 | 210 | 42758 | 126736 | 25240 | 0.0006 | 0.354 | 22.99 | 8.13 | 40.026 |
| 80 | 135 | 55 | 409 | 240 | 56485 | 167281 | 33100 | 0.0005 | 0.378 | 21.03 | 7.95 | 43.669 |
| 90 | 156 | 76 | 470 | 270 | 74602 | 220900 | 42740 | 0.0005 | 0.406 | 18.88 | 7.67 | 46.920 |
| 100 | 179 | 99 | 544 | 300 | 100058 | 295936 | 54930 | 0.0004 | 0.435 | 16.73 | 7.28 | 51.628 |
| 110 | 209 | 129 | 626 | 330 | 132366 | 391876 | 69450 | 0.0003 | 0.470 | 15.06 | 7.09 | 54.317 |
| 120 | 238 | 158 | 719 | 360 | 174309 | 516961 | 86910 | 0.0003 | 0.502 | 13.89 | 6.97 | 56.184 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130 | 272 | 192 | 825 | 390 | 229853 | 680625 | 108020 | 0.0003 | 0.537 | 12.71 | 6.82 | 62.189 |
| 140 | 315 | 235 | 943 | 420 | 299945 | 889249 | 132860 | 0.0002 | 0.578 | 11.59 | 6.70 | 64.814 |
| 150 | 356 | 276 | 1083 | 450 | 395705 | 1172889 | 163420 | 0.0002 | 0.614 | 10.48 | 6.43 | 69.919 |
| 160 | 412 | 332 | 1247 | 480 | 525921 | 1555009 | 200750 | 0.0002 | 0.661 | 9.39 | 6.20 | 78.526 |
| 170 | 479 | 399 | 1439 | 510 | 699489 | 2070721 | 245990 | 0.0001 | 0.712 | 8.33 | 5.93 | 82.465 |
| 180 | 548 | 468 | 1652 | 540 | 920370 | 2729104 | 298820 | 0.0001 | 0.762 | 7.27 | 5.54 | 85.483 |
| 190 | 625 | 545 | 1889 | 570 | 1203585 | 3568321 | 360590 | 0.0001 | 0.814 | 6.55 | 5.33 | 91.758 |
| 200 | 716 | 636 | 2154 | 600 | 1564250 | 4639716 | 432680 | 0.0001 | 0.871 | 5.83 | 5.08 | 96.970 |
| 210 | 813 | 733 | 2460 | 628 | 2040386 | 6051600 | 516888 | 0.0001 | 0.928 | 5.17 | 4.80 | 109.663 |
| 218 | 931 | 851 | | | | | | | 0.993 | 4.70 | 4.67 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_e$* | *$\dot{q}''_e . F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Hardboard – low preheat – ISO ign data – test 5** | Ignition Time | 67 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 80 | 0 | | | | | | | 0.291 | 33.88 | | |
| 20 | 83 | 3 | 250 | 60 | 20858 | 62500 | 5070 | 0.0028 | 0.296 | 32.87 | 9.75 | 18.772 |
| 30 | 87 | 7 | 262 | 90 | 22922 | 68644 | 7950 | 0.0022 | 0.304 | 32.16 | 9.76 | 21.257 |
| 40 | 92 | 12 | 279 | 120 | 26033 | 77841 | 11290 | 0.0015 | 0.312 | 29.67 | 9.26 | 25.720 |
| 50 | 100 | 20 | 303 | 150 | 30785 | 91809 | 15340 | 0.0010 | 0.325 | 27.17 | 8.84 | 30.950 |
| 60 | 111 | 31 | 336 | 180 | 37946 | 112896 | 20410 | 0.0008 | 0.343 | 24.95 | 8.55 | 35.440 |
| 70 | 125 | 45 | 377 | 210 | 47827 | 142129 | 26690 | 0.0007 | 0.364 | 22.99 | 8.37 | 38.759 |
| 80 | 141 | 61 | 427 | 240 | 61427 | 182329 | 34520 | 0.0006 | 0.386 | 21.03 | 8.13 | 42.514 |
| 90 | 161 | 81 | 488 | 270 | 80398 | 238144 | 44370 | 0.0004 | 0.413 | 18.88 | 7.80 | 47.532 |
| 100 | 186 | 106 | 563 | 300 | 107173 | 316969 | 56850 | 0.0004 | 0.444 | 16.73 | 7.42 | 52.513 |
| 110 | 216 | 136 | 648 | 330 | 141768 | 419904 | 71880 | 0.0003 | 0.478 | 15.06 | 7.20 | 54.772 |
| 120 | 246 | 166 | 744 | 360 | 186696 | 553536 | 89940 | 0.0003 | 0.510 | 13.89 | 7.09 | 57.525 |
| 130 | 282 | 202 | 847 | 390 | 241801 | 717409 | 110840 | 0.0003 | 0.547 | 12.71 | 6.95 | 60.417 |
| 140 | 319 | 239 | 972 | 420 | 318926 | 944784 | 136970 | 0.0002 | 0.581 | 11.59 | 6.74 | 67.023 |
| 150 | 371 | 291 | 1110 | 450 | 415802 | 1232100 | 167510 | 0.0002 | 0.627 | 10.48 | 6.57 | 71.074 |
| 160 | 420 | 340 | 1265 | 480 | 538717 | 1600225 | 203430 | 0.0002 | 0.667 | 9.39 | 6.26 | 71.792 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 170 | 474 | 394 | 1424 | 510 | 681976 | 2027776 | 243180 | 0.0002 | 0.709 | 8.33 | 5.90 | 74.166 |
| 180 | 530 | 450 | 1598 | 540 | 858412 | 2553604 | 288840 | 0.0002 | 0.749 | 7.27 | 5.45 | 77.517 |
| 190 | 594 | 514 | 1789 | 570 | 1075961 | 3200521 | 341260 | 0.0001 | 0.793 | 6.55 | 5.20 | 82.195 |
| 200 | 665 | 585 | 2001 | 600 | 1345625 | 4004001 | 401680 | 0.0001 | 0.839 | 5.83 | 4.89 | 86.047 |
| 210 | 742 | 662 | 2228 | 630 | 1666830 | 4963984 | 469440 | 0.0001 | 0.886 | 5.17 | 4.59 | 88.320 |
| 220 | 821 | 741 | 2451 | 660 | 2013149 | 6007401 | 540680 | 0.0001 | 0.932 | 4.58 | 4.27 | 85.536 |
| 230 | 888 | 808 | 2682 | 690 | 2409314 | 7193124 | 618380 | 0.0001 | 0.970 | 3.99 | 3.87 | 87.381 |
| 240 | 973 | 893 | 2936 | 720 | 2890898 | 8620096 | 706510 | 0.0001 | 1.000 | 3.77 | 3.77 | 96.828 |
| 250 | 1075 | 995 | 3206 | 750 | 3443318 | 10278436 | 803350 | 0.0001 | 1.000 | 3.54 | 3.54 | 96.346 |
| 260 | 1158 | 1078 | 3479 | 780 | 4049105 | 12103441 | 906250 | 0.0001 | 1.000 | 3.29 | 3.29 | 92.479 |
| 270 | 1246 | 1166 | | | | | | | 1.000 | 3.29 | 3.29 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – hardboard – Full preheat – test 1** | Ignition Time | 985 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | |
| 120 | 986 | 1 | | | | | | | 1.000 | 13.89 | | |
| 130 | 989 | 4 | 2975 | 390 | 2950317 | 8850625 | 386890 | 0.0013 | 1.000 | 12.71 | 12.71 | 27.860 |
| 140 | 1000 | 15 | 3007 | 420 | 3014445 | 9042049 | 421270 | 0.0007 | 1.000 | 11.59 | 11.59 | 38.447 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 1018 | 33 | 3061 | 450 | 3124173 | 9369721 | 459580 | 0.0005 | 1.000 | 10.48 | 10.48 | 46.572 |
| 160 | 1043 | 58 | 3136 | 480 | 3279798 | 9834496 | 502330 | 0.0003 | 1.000 | 9.39 | 9.39 | 53.519 |
| 170 | 1075 | 90 | 3227 | 510 | 3473355 | 10413529 | 549250 | 0.0003 | 1.000 | 8.33 | 8.33 | 57.454 |
| 180 | 1109 | 124 | 3339 | 540 | 3719531 | 11148921 | 601820 | 0.0002 | 1.000 | 7.27 | 7.27 | 63.482 |
| 190 | 1155 | 170 | 3459 | 570 | 3991931 | 11964681 | 658070 | 0.0002 | 1.000 | 6.55 | 6.55 | 65.628 |
| 200 | 1195 | 210 | 3597 | 600 | 4317059 | 12938409 | 720320 | 0.0002 | 1.000 | 5.83 | 5.83 | 68.015 |
| 210 | 1247 | 262 | 3744 | 630 | 4678238 | 14017536 | 787310 | 0.0002 | 1.000 | 5.17 | 5.17 | 73.153 |
| 220 | 1302 | 317 | 3924 | 660 | 5140838 | 15397776 | 864560 | 0.0002 | 1.000 | 4.58 | 4.58 | 80.263 |
| 230 | 1375 | 390 | 4127 | 690 | 5688329 | 17032129 | 950690 | 0.0001 | 1.000 | 3.99 | 3.99 | 86.026 |
| 240 | 1450 | 465 | 4343 | 720 | 6297449 | 18861649 | 1043750 | 0.0001 | 1.000 | 3.77 | 3.77 | 84.591 |
| 250 | 1518 | 533 | 4572 | 750 | 6979640 | 20903184 | 1144540 | 0.0001 | 1.000 | 3.54 | 3.54 | 87.949 |
| 260 | 1604 | 619 | 4813 | 780 | 7736621 | 23164969 | 1253110 | 0.0001 | 1.000 | 3.29 | 3.29 | 93.006 |
| 270 | 1691 | 706 | | | | | | | | 3.29 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – hardboard – Full preheat – test 2** | Ignition Time | 987 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | |
| 130 | 993 | 6 | | | | | | | | 12.71 | 0.00 | #DIV/0! |
| 140 | 1004 | 17 | 3017 | 420 | 3034465 | 9102289 | 422650 | 0.0007 | 1.000 | 11.59 | 11.59 | 36.952 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 1020 | 33 | 3063 | 450 | 3127937 | 9381969 | 459800 | 0.0006 | 1.000 | 10.48 | 10.48 | 41.884 |
| 160 | 1039 | 52 | 3127 | 480 | 3260545 | 9778129 | 500800 | 0.0004 | 1.000 | 9.39 | 9.39 | 49.343 |
| 170 | 1068 | 81 | 2107 | 340 | 2220145 | 4439449 | 347800 | 0.0001 | 1.000 | 8.33 | 8.33 | 82.411 |
| 180 | 1101 | 114 | 2169 | 370 | 2352825 | 4704561 | 379740 | 0.0001 | 1.000 | 7.27 | 7.27 | 83.614 |
| 190 | 1140 | 153 | 2241 | 400 | 2511801 | 5022081 | 414780 | 0.0001 | 1.000 | 6.55 | 6.55 | 84.991 |
| 200 | 1186 | 199 | 2326 | 430 | 2706196 | 5410276 | 453800 | 0.0001 | 1.000 | 5.83 | 5.83 | 86.589 |
| 210 | 1233 | 246 | 2419 | 460 | 2926885 | 5851561 | 496130 | 0.0001 | 1.000 | 5.17 | 5.17 | 88.303 |
| 220 | 1286 | 299 | 2519 | 490 | 3174085 | 6345361 | 541850 | 0.0001 | 1.000 | 4.58 | 4.58 | 90.111 |
| 230 | 1350 | 363 | 2636 | 520 | 3476296 | 6948496 | 593420 | 0.0001 | 1.000 | 3.99 | 3.99 | 92.186 |
| 240 | 1408 | 421 | 2758 | 550 | 3804964 | 7606564 | 648420 | 0.0001 | 1.000 | 3.77 | 3.77 | 94.289 |
| 250 | 1477 | 490 | 2885 | 580 | 4163993 | 8323225 | 707170 | 0.0001 | 1.000 | 3.54 | 3.54 | 96.441 |
| 260 | 1556 | 569 | 3033 | 610 | 4602665 | 9199089 | 773810 | 0.0001 | 1.000 | 3.29 | 3.29 | 98.890 |
| 270 | 1626 | 639 | 3182 | 640 | 5065012 | 10125124 | 843580 | 0.0001 | 1.000 | 3.29 | 3.29 | 101.280 |
| 280 | 1674 | 687 | | | | | | | | 2.89 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – hardboard – Full preheat – test 3** | Ignition Time | 987 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | |
| 130 | 994 | 7 | | | | | | | | 12.71 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 | 1001 | 14 | 3012 | 420 | 3024326 | 9072144 | 421910 | 0.0008 | 1.000 | 11.59 | 11.59 | 34.766 |
| 150 | 1017 | 30 | 3056 | 450 | 3113734 | 9339136 | 458770 | 0.0005 | 1.000 | 10.48 | 10.48 | 43.142 |
| 160 | 1038 | 51 | 2055 | 370 | 2111733 | 4223025 | 318630 | 0.0001 | 1.000 | 9.39 | 9.39 | 103.931 |
| 170 | 1066 | 79 | 2104 | 400 | 2213800 | 4426816 | 347300 | 0.0001 | 1.000 | 8.33 | 8.33 | 105.149 |
| 180 | 1100 | 113 | 2166 | 430 | 2346356 | 4691556 | 379220 | 0.0001 | 1.000 | 7.27 | 7.27 | 106.678 |
| 190 | 1077 | 90 | 2177 | 460 | 2369929 | 4739329 | 402630 | 0.0001 | 1.000 | 6.55 | 6.55 | 107.149 |
| 200 | 1182 | 195 | 2259 | 490 | 2557053 | 5103081 | 441030 | 0.0001 | 1.000 | 5.83 | 5.83 | 108.992 |
| 210 | 1227 | 240 | 2409 | 520 | 2902653 | 5803281 | 494070 | 0.0001 | 1.000 | 5.17 | 5.17 | 112.494 |
| 220 | 1290 | 303 | 3503 | 550 | 4141825 | 12271009 | 659790 | 0.0003 | 1.000 | 4.58 | 4.58 | 54.129 |
| 230 | 1358 | 371 | 3636 | 580 | 4484408 | 13220496 | 724580 | 0.0003 | 1.000 | 3.99 | 3.99 | 59.901 |
| 240 | 1423 | 436 | 3787 | 610 | 4881129 | 14341369 | 794700 | 0.0002 | 1.000 | 3.77 | 3.77 | 63.872 |
| 250 | 1505 | 518 | 3950 | 640 | 5334438 | 15602500 | 871070 | 0.0002 | 1.000 | 3.54 | 3.54 | 68.585 |
| 260 | 1585 | 598 | 4135 | 670 | 5869275 | 17098225 | 955550 | 0.0002 | 1.000 | 3.29 | 3.29 | 72.783 |
| 270 | 1691 | 704 | | | | | | | | 3.29 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – hardboard – Full preheat – test 4** | Ignition Time | 982 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 986 | 4 | | | | | | | | 13.89 | | | |
| 130 | 988 | 6 | 2980 | 390 | 2960376 | 8880400 | 387600 | 0.0008 | 1.000 | 12.71 | 12.71 | 34.833 |
| 140 | 1006 | 24 | 3016 | 420 | 3032664 | 9096256 | 422580 | 0.0006 | 1.000 | 11.59 | 11.59 | 41.255 |
| 150 | 1022 | 40 | 3073 | 450 | 3148545 | 9443329 | 461340 | 0.0005 | 1.000 | 10.48 | 10.48 | 44.395 |
| 160 | 1045 | 63 | 3137 | 480 | 3281409 | 9840769 | 502400 | 0.0004 | 1.000 | 9.39 | 9.39 | 49.004 |
| 170 | 1070 | 88 | 3219 | 510 | 3455741 | 10361961 | 547820 | 0.0003 | 1.000 | 8.33 | 8.33 | 54.524 |
| 180 | 1104 | 122 | 3316 | 540 | 3667880 | 10995856 | 597600 | 0.0003 | 1.000 | 7.27 | 7.27 | 60.031 |
| 190 | 1142 | 160 | 3410 | 570 | 3877876 | 11628100 | 648500 | 0.0003 | 1.000 | 6.55 | 6.55 | 55.418 |
| 200 | 1164 | 182 | 3532 | 600 | 4162136 | 12475024 | 707240 | 0.0002 | 1.000 | 5.83 | 5.83 | 67.212 |
| 210 | 1226 | 244 | 3668 | 630 | 4491256 | 13454224 | 771420 | 0.0002 | 1.000 | 5.17 | 5.17 | 75.595 |
| 220 | 1278 | 296 | 3835 | 660 | 4907921 | 14707225 | 844750 | 0.0002 | 1.000 | 4.58 | 4.58 | 72.458 |
| 230 | 1331 | 349 | 4000 | 690 | 5339726 | 16000000 | 921130 | 0.0002 | 1.000 | 3.99 | 3.99 | 75.215 |
| 240 | 1391 | 409 | 4186 | 720 | 5849738 | 17522596 | 1005970 | 0.0001 | 1.000 | 3.77 | 3.77 | 81.677 |
| 250 | 1464 | 482 | 4388 | 750 | 6428266 | 19254544 | 1098420 | 0.0001 | 1.000 | 3.54 | 3.54 | 84.273 |
| 260 | 1533 | 551 | 4600 | 780 | 7062994 | 21160000 | 1197390 | 0.0001 | 1.000 | 3.29 | 3.29 | 83.367 |
| 270 | 1603 | 621 | 4829 | 806 | 7785947 | 23319241 | 1298658 | 0.0001 | 1.000 | 3.29 | 3.29 | 100.786 |
| 276 | 1693 | 711 | | | | | | | | 3.05 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – hardboard – Full preheat – test 5** | Ignition Time | 1054 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | |
| 130 | 1062 | 8 | | | | | | | | 12.71 | | |
| 140 | 1069 | 15 | 3215 | 420 | 3445661 | 10336225 | 450320 | 0.0009 | 1.000 | 11.59 | 11.59 | 33.889 |
| 150 | 1084 | 30 | 3257 | 450 | 3536633 | 10608049 | 488900 | 0.0006 | 1.000 | 10.48 | 10.48 | 41.975 |
| 160 | 1104 | 50 | 3316 | 480 | 3666256 | 10995856 | 531000 | 0.0005 | 1.000 | 9.39 | 9.39 | 46.969 |
| 170 | 1128 | 74 | 3392 | 510 | 3836800 | 11505664 | 577200 | 0.0004 | 1.000 | 8.33 | 8.33 | 53.095 |
| 180 | 1160 | 106 | 3488 | 540 | 4057984 | 12166144 | 628560 | 0.0003 | 1.000 | 7.27 | 7.27 | 60.123 |
| 190 | 1200 | 146 | 3598 | 570 | 4318244 | 12945604 | 684400 | 0.0003 | 1.000 | 6.55 | 6.55 | 62.457 |
| 200 | 1238 | 184 | 3728 | 600 | 4636744 | 13897984 | 746500 | 0.0002 | 1.000 | 5.83 | 5.83 | 67.352 |
| 210 | 1290 | 236 | 3888 | 630 | 5046344 | 15116544 | 817700 | 0.0002 | 1.000 | 5.17 | 5.17 | 78.385 |
| 220 | 1360 | 306 | 4074 | 660 | 5541476 | 16597476 | 897620 | 0.0001 | 1.000 | 4.58 | 4.58 | 81.881 |
| 230 | 1424 | 370 | 4284 | 690 | 6127376 | 18352656 | 986720 | 0.0001 | 1.000 | 3.99 | 3.99 | 83.768 |
| 240 | 1500 | 446 | 4522 | 715 | 6831380 | 20448484 | 1079030 | 0.0001 | 1.000 | 3.77 | 3.77 | 108.757 |
| 245 | 1598 | 544 | | | | | | | | 3.66 | | |

**Particle board**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LIFT-Pynefloor particle Board – test 1 | Ignition Time | 396 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | 404 | 8 | | | | | | | 1.000 | 24.24 | | |
| 150 | 409 | 13 | 1230 | 450 | 504386 | 1512900 | 184825 | 0.0038 | 1.000 | 23.10 | 23.10 | 16.267 |
| 175 | 417 | 21 | 1254 | 525 | 524354 | 1572516 | 219925 | 0.0026 | 1.000 | 21.67 | 21.67 | 19.574 |
| 200 | 428 | 32 | 1282 | 600 | 548042 | 1643524 | 256900 | 0.0025 | 1.000 | 20.25 | 20.25 | 20.033 |
| 225 | 437 | 41 | 1311 | 675 | 573069 | 1718721 | 295425 | 0.0028 | 1.000 | 19.18 | 19.18 | 18.974 |
| 250 | 446 | 50 | 1358 | 750 | 615510 | 1844164 | 340450 | 0.0012 | 1.000 | 18.11 | 18.11 | 28.813 |
| 275 | 475 | 79 | 1432 | 825 | 685662 | 2050624 | 395425 | 0.0008 | 1.000 | 16.40 | 16.40 | 36.125 |
| 300 | 511 | 115 | 1533 | 900 | 785955 | 2350089 | 461700 | 0.0007 | 1.000 | 14.70 | 14.70 | 37.947 |
| 325 | 547 | 151 | 1650 | 975 | 910794 | 2722500 | 538275 | 0.0006 | 1.000 | 12.98 | 12.98 | 40.332 |
| 350 | 592 | 196 | 1804 | 1050 | 1091898 | 3254416 | 634350 | 0.0004 | 1.000 | 11.27 | 11.27 | 49.034 |
| 375 | 665 | 269 | 2019 | 1125 | 1373333 | 4076361 | 761375 | 0.0003 | 1.000 | 9.94 | 9.94 | 58.503 |
| 400 | 762 | 366 | 2311 | 1200 | 1804325 | 5340721 | 929875 | 0.0002 | 1.000 | 8.62 | 8.62 | 66.325 |
| 425 | 884 | 488 | 2658 | 1275 | 2386244 | 7064964 | 1135900 | 0.0002 | 1.000 | 7.44 | 7.44 | 70.717 |
| 450 | 1012 | 616 | 3039 | 1335 | 3112049 | 9235521 | 1356880 | 0.0001 | 1.000 | 6.25 | 6.25 | 86.096 |
| 460 | 1143 | 747 | | | | | | | 1.000 | 5.89 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT-Pynefloor particle Board – test 2** | Ignition Time | 391 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | 391 | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 75 | 391 | | | | | | | | | | | |
| 100 | 391 | | | | | | | | | | | |
| 125 | 391 | | | | | | | | | | | |
| 150 | 391 | | | | | | | | | | | |
| 175 | 391 | | | | | | | | | | | |
| 200 | 391 | | | | | | | | | | | |
| 225 | 395 | 4 | | | | | | | 1.000 | 19.18 | | |
| 250 | 400 | 9 | 1223 | 750 | 499209 | 1495729 | 306575 | 0.0013 | 1.000 | 18.11 | 18.11 | 27.692 |
| 275 | 428 | 37 | 1281 | 825 | 548393 | 1640961 | 353600 | 0.0009 | 1.000 | 16.40 | 16.40 | 32.575 |
| 300 | 453 | 62 | 1386 | 900 | 643418 | 1920996 | 417725 | 0.0006 | 1.000 | 14.70 | 14.70 | 40.039 |
| 325 | 505 | 114 | 1546 | 975 | 805978 | 2390116 | 505825 | 0.0004 | 1.000 | 12.98 | 12.98 | 52.416 |
| 350 | 588 | 197 | 1743 | 1050 | 1023269 | 3038049 | 613675 | 0.0003 | 1.000 | 11.27 | 11.27 | 54.040 |
| 375 | 650 | 259 | 1996 | 1125 | 1342808 | 3984016 | 752750 | 0.0003 | 1.000 | 9.94 | 9.94 | 59.017 |
| 400 | 758 | 367 | 2280 | 1200 | 1757448 | 5198400 | 917550 | 0.0002 | 1.000 | 8.62 | 8.62 | 66.641 |
| 425 | 872 | 481 | 2622 | 1256 | 1334948 | 6874884 | 673800 | 0.0004 | 1.000 | 7.44 | 7.44 | 47.504 |
| 431 | 992 | 601 | | | | | | | 1.000 | 7.15 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT-Pynefloor particle Board – test 3** | Ignition Time | 393 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 225 | 400 | 7 | | | | | | | | 19.18 | | |
| 250 | 407 | 14 | 1226 | 750 | 501210 | 1503076 | 306975 | 0.0026 | 1.000 | 18.11 | 18.11 | 19.717 |
| 275 | 419 | 26 | 1269 | 825 | 537459 | 1610361 | 349875 | 0.0013 | 1.000 | 16.40 | 16.40 | 27.325 |
| 300 | 443 | 50 | 1336 | 900 | 596486 | 1784896 | 402175 | 0.0009 | 1.000 | 14.70 | 14.70 | 33.256 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 325 | 474 | 81 | 1440 | 975 | 694454 | 2073600 | 470000 | 0.0006 | 1.000 | 12.98 | 12.98 | 40.336 |
| 350 | 523 | 130 | 1572 | 1050 | 828830 | 2471184 | 552725 | 0.0005 | 1.000 | 11.27 | 11.27 | 44.951 |
| 375 | 575 | 182 | 1755 | 1125 | 1035803 | 3080025 | 661475 | 0.0004 | 1.000 | 9.94 | 9.94 | 52.199 |
| 400 | 657 | 264 | 1985 | 1200 | 1329283 | 3940225 | 798450 | 0.0003 | 1.000 | 8.62 | 8.62 | 59.727 |
| 425 | 753 | 360 | 2321 | 1275 | 998658 | 5387041 | 992775 | -0.00001 | 1.000 | 7.44 | 7.44 | |
| 450 | 911 | 518 | 2689 | 1335 | 1396930 | 7230721 | 1201475 | 0.00000 | 1.000 | 6.25 | 6.25 | |
| 460 | 1025 | 632 | | | | | | | 1.000 | 5.89 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – pynefloor particle board – low preheat – ISO ign data – test 1** | Ignition Time | 75 | | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 75 | 0 | | | | | | | | 33.82 | | |
| 20 | 77 | 2 | 231 | 60 | 17795 | 53361 | 4660 | 0.0050 | 0.319 | 32.76 | 10.46 | 14.142 |
| 30 | 79 | 4 | 237 | 90 | 18731 | 56169 | 7150 | 0.0050 | 0.324 | 31.96 | 10.34 | 14.142 |
| 40 | 81 | 6 | 250 | 120 | 20902 | 62500 | 10110 | 0.0016 | 0.328 | 29.56 | 9.68 | 24.985 |
| 50 | 90 | 15 | 271 | 150 | 24661 | 73441 | 13740 | 0.0011 | 0.345 | 27.16 | 9.38 | 30.836 |
| 60 | 100 | 25 | 300 | 180 | 30200 | 90000 | 18200 | 0.0010 | 0.364 | 24.97 | 9.09 | 31.623 |
| 70 | 110 | 35 | 335 | 210 | 37725 | 112225 | 23700 | 0.0008 | 0.382 | 22.98 | 8.77 | 35.590 |
| 80 | 125 | 50 | 380 | 240 | 48750 | 144400 | 30750 | 0.0006 | 0.407 | 20.99 | 8.54 | 41.975 |
| 90 | 145 | 70 | 440 | 270 | 65550 | 193600 | 40050 | 0.0004 | 0.438 | 18.76 | 8.22 | 47.532 |
| 100 | 170 | 95 | 510 | 300 | 87950 | 260100 | 51500 | 0.0004 | 0.475 | 16.53 | 7.85 | 50.000 |
| 110 | 195 | 120 | 593 | 330 | 118909 | 351649 | 65810 | 0.0003 | 0.508 | 14.65 | 7.45 | 54.022 |
| 120 | 228 | 153 | 698 | 360 | 165634 | 487204 | 84560 | 0.0002 | 0.550 | 13.12 | 7.21 | 63.568 |
| 130 | 275 | 200 | 821 | 390 | 228733 | 674041 | 107630 | 0.0002 | 0.604 | 11.59 | 7.00 | 67.104 |
| 140 | 318 | 243 | 966 | 420 | 315878 | 933156 | 136220 | 0.0002 | 0.649 | 10.50 | 6.81 | 70.175 |
| 150 | 373 | 298 | 1314 | 450 | 628382 | 1726596 | 200150 | 0.0001 | 0.703 | 9.40 | 6.61 | 131.635 |
| 160 | 623 | 548 | 1667 | 475 | 977499 | 2778889 | 266345 | 0.0000 | 0.909 | 8.39 | 7.63 | 145.962 |
| 165 | 671 | 596 | | | | | | | 0.943 | 7.94 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – pynefloor particle board – low preheat – ISO ign data – test 2** | Ignition Time | 65 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 65 | 0 | | | | | | | | 33.82 | | |
| 20 | 68 | 3 | 204 | 60 | 13890 | 41616 | 4140 | 0.0033 | 0.300 | 32.76 | 9.83 | 17.321 |
| 30 | 71 | 6 | 213 | 90 | 15141 | 45369 | 6450 | 0.0033 | 0.307 | 31.96 | 9.80 | 17.321 |
| 40 | 74 | 9 | 226 | 120 | 17078 | 51076 | 9140 | 0.0019 | 0.313 | 29.56 | 9.26 | 22.949 |
| 50 | 81 | 16 | 249 | 150 | 20873 | 62001 | 12650 | 0.0010 | 0.328 | 27.16 | 8.90 | 32.094 |
| 60 | 94 | 29 | 279 | 180 | 26213 | 77841 | 16970 | 0.0009 | 0.353 | 24.97 | 8.81 | 34.008 |
| 70 | 104 | 39 | 320 | 210 | 34536 | 102400 | 22680 | 0.0007 | 0.371 | 22.98 | 8.53 | 37.922 |
| 80 | 122 | 57 | 368 | 240 | 45864 | 135424 | 29820 | 0.0005 | 0.402 | 20.99 | 8.44 | 43.609 |
| 90 | 142 | 77 | 449 | 270 | 69273 | 201601 | 41040 | 0.0003 | 0.434 | 18.76 | 8.14 | 57.358 |
| 100 | 185 | 120 | 521 | 300 | 92025 | 271441 | 52620 | 0.0003 | 0.495 | 16.53 | 8.19 | 54.502 |
| 110 | 194 | 129 | 608 | 330 | 124302 | 369664 | 67320 | 0.0004 | 0.507 | 14.65 | 7.43 | 49.559 |
| 120 | 229 | 164 | 703 | 360 | 168477 | 494209 | 85220 | 0.0002 | 0.551 | 13.12 | 7.23 | 65.952 |
| 130 | 280 | 215 | 842 | 390 | 241730 | 708964 | 110500 | 0.0002 | 0.609 | 11.59 | 7.06 | 72.115 |
| 140 | 333 | 268 | 1005 | 420 | 342953 | 1010025 | 141820 | 0.0002 | 0.664 | 10.50 | 6.97 | 74.869 |
| 150 | 392 | 327 | | | | | | | 0.721 | 9.40 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – pynefloor particle board – low preheat – ISO ign data – test 3** | Ignition Time | 71 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 71 | 0 | | | | | | | 0.307 | 33.82 | | |
| 20 | 76 | 5 | 227 | 60 | 17217 | 51529 | 4630 | 0.0022 | 0.317 | 32.76 | 10.40 | 21.257 |
| 30 | 80 | 9 | 244 | 90 | 19920 | 59536 | 7440 | 0.0016 | 0.326 | 31.96 | 10.41 | 24.944 |
| 40 | 88 | 17 | 272 | 120 | 24960 | 73984 | 11120 | 0.0008 | 0.341 | 29.56 | 10.09 | 35.277 |
| 50 | 104 | 33 | 310 | 150 | 32484 | 96100 | 15800 | 0.0007 | 0.371 | 27.16 | 10.08 | 38.759 |
| 60 | 118 | 47 | 362 | 180 | 44340 | 131044 | 22080 | 0.0005 | 0.395 | 24.97 | 9.87 | 42.774 |
| 70 | 140 | 69 | 419 | 210 | 59445 | 175561 | 29760 | 0.0005 | 0.431 | 22.98 | 9.90 | 46.372 |
| 80 | 161 | 90 | 483 | 240 | 78645 | 233289 | 39060 | 0.0005 | 0.462 | 20.99 | 9.69 | 45.826 |
| 90 | 182 | 111 | 555 | 270 | 103989 | 308025 | 50460 | 0.0004 | 0.491 | 18.76 | 9.21 | 50.759 |
| 100 | 212 | 141 | 640 | 300 | 138584 | 409600 | 64640 | 0.0003 | 0.530 | 16.53 | 8.76 | 56.605 |
| 110 | 246 | 175 | 752 | 330 | 191896 | 565504 | 83540 | 0.0002 | 0.571 | 14.65 | 8.37 | 64.342 |
| 120 | 294 | 223 | 1012 | 360 | 369736 | 1024144 | 123700 | 0.0001 | 0.624 | 13.12 | 8.19 | 112.010 |
| 130 | 472 | 401 | 1280 | 390 | 573416 | 1638400 | 168600 | 0.0001 | 0.791 | 11.59 | 9.17 | 111.361 |
| 140 | 514 | 443 | 1572 | 420 | 830376 | 2471184 | 221220 | 0.0002 | 0.825 | 10.50 | 8.66 | 76.365 |
| 150 | 586 | 515 | 1749 | 441 | 1028793 | 3059001 | 257859 | 0.0001 | 0.881 | 9.40 | 8.28 | 109.870 |
| 151 | 649 | 578 | | | | | | | 0.927 | 9.30 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – pynefloor particle board – low preheat – ISO ign data – test 4** | Ignition Time | 80 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 80 | 0 | | | | | | | 0.326 | 33.82 | | |
| 20 | 82 | 2 | 249 | 60 | 20693 | 62001 | 5050 | 0.0027 | 0.330 | 32.76 | 10.80 | 19.272 |
| 30 | 87 | 7 | 258 | 90 | 22214 | 66564 | 7810 | 0.0027 | 0.340 | 31.96 | 10.85 | 19.272 |
| 40 | 89 | 9 | 273 | 120 | 24899 | 74529 | 11020 | 0.0018 | 0.343 | 29.56 | 10.15 | 23.664 |
| 50 | 97 | 17 | 295 | 150 | 29211 | 87025 | 14950 | 0.0010 | 0.359 | 27.16 | 9.74 | 31.833 |
| 60 | 109 | 29 | 329 | 180 | 36419 | 108241 | 20000 | 0.0008 | 0.380 | 24.97 | 9.49 | 36.091 |
| 70 | 123 | 43 | 373 | 210 | 46891 | 139129 | 26430 | 0.0006 | 0.404 | 22.98 | 9.28 | 40.104 |
| 80 | 141 | 61 | 427 | 240 | 61579 | 182329 | 34560 | 0.0005 | 0.432 | 20.99 | 9.07 | 44.796 |
| 90 | 163 | 83 | 499 | 270 | 84475 | 249001 | 45450 | 0.0004 | 0.465 | 18.76 | 8.72 | 52.258 |
| 100 | 195 | 115 | 579 | 300 | 113435 | 335241 | 58480 | 0.0003 | 0.508 | 16.53 | 8.40 | 53.948 |
| 110 | 221 | 141 | 680 | 330 | 156562 | 462400 | 75490 | 0.0003 | 0.541 | 14.65 | 7.93 | 59.328 |
| 120 | 264 | 184 | 789 | 360 | 210953 | 622521 | 95510 | 0.0002 | 0.591 | 13.12 | 7.76 | 64.435 |
| 130 | 304 | 224 | 1171 | 390 | 525721 | 1371241 | 155620 | 0.0000 | 0.635 | 11.59 | 7.36 | 142.295 |
| 140 | 603 | 523 | 1551 | 420 | 870761 | 2405601 | 220540 | 0.0000 | 0.894 | 10.50 | 9.38 | 142.348 |
| 150 | 644 | 564 | 1938 | 450 | 1255826 | 3755844 | 291580 | 0.0002 | 0.924 | 9.40 | 8.68 | 66.384 |
| 160 | 691 | 611 | 2145 | 474 | 1548317 | 4601025 | 340000 | 0.0001 | 0.957 | 8.39 | 8.03 | 115.901 |
| 164 | 810 | 730 | | | | | | | 1.000 | 8.03 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – pynefloor particle board – low preheat – ISO ign data – test 5** | Ignition Time | 82 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 82 | 0 | | | | | | | 0.330 | 33.82 | | |
| 20 | 85 | 3 | 258 | 60 | 22230 | 66564 | 5250 | 0.0021 | 0.336 | 32.76 | 10.99 | 21.602 |
| 30 | 91 | 9 | 270 | 90 | 24342 | 72900 | 8190 | 0.0021 | 0.347 | 31.96 | 11.10 | 21.602 |
| 40 | 94 | 12 | 283 | 120 | 26721 | 80089 | 11390 | 0.0028 | 0.353 | 29.56 | 10.43 | 18.772 |
| 50 | 98 | 16 | 303 | 150 | 30761 | 91809 | 15320 | 0.0011 | 0.360 | 27.16 | 9.79 | 30.486 |
| 60 | 111 | 29 | 335 | 180 | 37801 | 112225 | 20380 | 0.0007 | 0.384 | 24.97 | 9.58 | 37.448 |
| 70 | 126 | 44 | 379 | 210 | 48361 | 143641 | 26840 | 0.0006 | 0.409 | 22.98 | 9.39 | 39.377 |
| 80 | 142 | 60 | 428 | 240 | 61640 | 183184 | 34580 | 0.0006 | 0.434 | 20.99 | 9.10 | 41.255 |
| 90 | 160 | 78 | 493 | 270 | 82245 | 243049 | 44860 | 0.0004 | 0.460 | 18.76 | 8.64 | 50.075 |
| 100 | 191 | 109 | 571 | 300 | 110481 | 326041 | 57700 | 0.0003 | 0.503 | 16.53 | 8.32 | 54.782 |
| 110 | 220 | 138 | 670 | 330 | 151962 | 448900 | 74380 | 0.0003 | 0.540 | 14.65 | 7.91 | 58.519 |
| 120 | 259 | 177 | 789 | 360 | 211581 | 622521 | 95580 | 0.0002 | 0.586 | 13.12 | 7.69 | 67.281 |
| 130 | 310 | 228 | 938 | 390 | 299342 | 879844 | 123040 | 0.0002 | 0.641 | 11.59 | 7.43 | 74.227 |
| 140 | 369 | 287 | 1114 | 420 | 421486 | 1240996 | 157210 | 0.0002 | 0.699 | 10.50 | 7.34 | 79.098 |
| 150 | 435 | 353 | 1327 | 450 | 598915 | 1760929 | 200590 | 0.0001 | 0.759 | 9.40 | 7.14 | 88.048 |
| 160 | 523 | 441 | 1570 | 473 | 837298 | 2464900 | 248686 | 0.0001 | 0.833 | 8.39 | 6.99 | 116.745 |
| 163 | 612 | 530 | | | | | | | 0.901 | 8.12 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – pynefloor particle board – low preheat – ISO ign data – test 6** | Ignition Time | 78 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 78 | 0 | | | | | | | 0.322 | 33.82 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 81 | 2.5 | 242 | 60 | 19453 | 58322 | 4880 | 0.0040 | 0.327 | 32.76 | 10.70 | 15.811 |
| 30 | 83 | 5 | 252 | 90 | 21113 | 63252 | 7620 | 0.0026 | 0.332 | 31.96 | 10.60 | 19.720 |
| 40 | 88 | 10 | 266 | 120 | 23658 | 70756 | 10760 | 0.0017 | 0.341 | 29.56 | 10.09 | 24.608 |
| 50 | 95 | 17 | 285 | 150 | 27173 | 81225 | 14390 | 0.0014 | 0.355 | 27.16 | 9.64 | 26.458 |
| 60 | 102 | 24 | 310 | 180 | 32198 | 96100 | 18780 | 0.0011 | 0.368 | 24.97 | 9.18 | 30.246 |
| 70 | 113 | 35 | 335 | 210 | 37573 | 112225 | 23630 | 0.0011 | 0.387 | 22.98 | 8.89 | 30.246 |
| 80 | 120 | 42 | 367 | 240 | 45125 | 134689 | 29570 | 0.0009 | 0.399 | 20.99 | 8.37 | 32.998 |
| 90 | 134 | 56 | 410 | 270 | 56692 | 168100 | 37260 | 0.0005 | 0.421 | 18.76 | 7.90 | 42.774 |
| 100 | 156 | 78 | 475 | 300 | 76517 | 225625 | 48010 | 0.0004 | 0.455 | 16.53 | 7.52 | 50.656 |
| 110 | 185 | 107 | 563 | 330 | 107845 | 316969 | 62590 | 0.0003 | 0.495 | 14.65 | 7.26 | 57.586 |
| 120 | 222 | 144 | 666 | 360 | 150590 | 443556 | 80660 | 0.0003 | 0.542 | 13.12 | 7.12 | 60.828 |
| 130 | 259 | 181 | 790 | 390 | 211846 | 624100 | 103570 | 0.0002 | 0.586 | 11.59 | 6.79 | 66.200 |
| 140 | 309 | 231 | 940 | 420 | 300946 | 883600 | 132730 | 0.0002 | 0.640 | 10.50 | 6.72 | 75.332 |
| 150 | 372 | 294 | | | | | | | 0.702 | 9.40 | | |

**Test 1 - half preheat**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – half preheat – ISO ign data – test 1** | Ignition Time | 386 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | 390 | 4 | | | | | | | | | | |
| 60 | 392 | 6 | | | | | | | 0.72 | 24.97 | | |
| 70 | 400 | 14 | 1199 | 210 | 479313 | 1437601 | 84080 | 0.0013 | 0.73 | 22.98 | 16.73 | 27.406 |
| 80 | 407 | 21 | 1217 | 240 | 493749 | 1481089 | 97460 | 0.0019 | 0.73 | 20.99 | 15.41 | 22.949 |
| 90 | 410 | 24 | 1231 | 270 | 505145 | 1515361 | 110860 | 0.0028 | 0.74 | 18.76 | 13.83 | 18.772 |
| 100 | 414 | 28 | 1251 | 300 | 521825 | 1565001 | 125270 | 0.0011 | 0.74 | 16.53 | 12.25 | 30.486 |
| 110 | 427 | 41 | 1286 | 330 | 551750 | 1653796 | 141770 | 0.0006 | 0.75 | 14.65 | 11.02 | 39.540 |
| 120 | 445 | 59 | 1348 | 360 | 606930 | 1817104 | 162250 | 0.0004 | 0.77 | 13.12 | 10.08 | 50.075 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130 | 476 | 90 | 1432 | 390 | 685722 | 2050624 | 186820 | 0.0003 | 0.79 | 11.59 | 9.21 | 57.481 |
| 140 | 511 | 125 | 1542 | 420 | 795722 | 2377764 | 216670 | 0.0003 | 0.82 | 10.50 | 8.64 | 62.985 |
| 150 | 555 | 169 | 1680 | 450 | 946142 | 2822400 | 253030 | 0.0002 | 0.86 | 9.40 | 8.06 | 72.017 |
| 160 | 614 | 228 | 1834 | 480 | 1127246 | 3363556 | 294540 | 0.0002 | 0.90 | 8.39 | 7.57 | 74.227 |
| 170 | 665 | 279 | 2044 | 510 | 1404446 | 4177936 | 348990 | 0.0001 | 0.94 | 7.48 | 7.02 | 88.403 |
| 180 | 765 | 379 | 2275 | 540 | 1741475 | 5175625 | 411300 | 0.0001 | 1.00 | 6.57 | 6.57 | 95.063 |
| 190 | 845 | 459 | | | | | | | 1.00 | 5.93 | 5.93 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – half preheat – ISO ign data – test 2** | Ignition Time | 385 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | 386 | 1 | | | | | | | 0.715 | 20.99 | | |
| 90 | 392 | 7 | 1178 | 270 | 462660 | 1387684 | 106160 | 0.0014 | 0.721 | 18.76 | 13.52 | 26.547 |
| 100 | 400 | 15 | 1212 | 300 | 490064 | 1468944 | 121480 | 0.0007 | 0.728 | 16.53 | 12.04 | 38.545 |
| 110 | 420 | 35 | 1258 | 330 | 528244 | 1582564 | 138760 | 0.0005 | 0.746 | 14.65 | 10.93 | 43.609 |
| 120 | 438 | 53 | 1326 | 360 | 587268 | 1758276 | 159600 | 0.0004 | 0.762 | 13.12 | 10.00 | 49.497 |
| 130 | 468 | 83 | 1411 | 390 | 665893 | 1990921 | 184100 | 0.0003 | 0.788 | 11.59 | 9.13 | 57.984 |
| 140 | 505 | 120 | 1534 | 420 | 788770 | 2353156 | 215690 | 0.0002 | 0.818 | 10.50 | 8.59 | 68.664 |
| 150 | 561 | 176 | 1697 | 450 | 967907 | 2879809 | 255810 | 0.0002 | 0.862 | 9.40 | 8.10 | 79.536 |
| 160 | 631 | 246 | 1895 | 475 | 1207091 | 3591025 | 301105 | 0.0001 | 0.914 | 8.39 | 7.68 | 97.376 |
| 165 | 703 | 318 | | | | | | | 0.965 | 7.94 | 7.66 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – half preheat – ISO ign data – test 3** | Ignition Time | 386 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | 389 | 3 | | | | | | | 0.718 | 20.99 | | |
| 90 | 393 | 7 | 1183 | 270 | 466571 | 1399489 | 106590 | 0.0016 | 0.722 | 18.76 | 13.54 | 24.944 |
| 100 | 401 | 15 | 1209 | 300 | 487475 | 1461681 | 121120 | 0.0009 | 0.729 | 16.53 | 12.05 | 33.575 |
| 110 | 415 | 29 | 1252 | 330 | 523122 | 1567504 | 138070 | 0.0006 | 0.742 | 14.65 | 10.87 | 42.111 |
| 120 | 436 | 50 | 1312 | 360 | 574842 | 1721344 | 157900 | 0.0004 | 0.760 | 13.12 | 9.98 | 48.019 |
| 130 | 461 | 75 | 1400 | 390 | 655626 | 1960000 | 182670 | 0.0003 | 0.782 | 11.59 | 9.06 | 58.497 |
| 140 | 503 | 117 | 1518 | 420 | 772446 | 2304324 | 213450 | 0.0002 | 0.816 | 10.50 | 8.57 | 68.297 |
| 150 | 554 | 168 | 1671 | 450 | 936921 | 2792241 | 251760 | 0.0002 | 0.857 | 9.40 | 8.05 | 74.580 |
| 160 | 614 | 228 | 1839 | 480 | 1134153 | 3381921 | 295410 | 0.0002 | 0.902 | 8.39 | 7.57 | 76.494 |
| 170 | 671 | 285 | 2052 | 510 | 1415526 | 4210704 | 350370 | 0.0001 | 0.943 | 7.48 | 7.05 | 88.406 |
| 180 | 767 | 381 | 2323 | 538 | 1821755 | 5396329 | 418510 | 0.0001 | 1.000 | 6.57 | 6.57 | 109.437 |
| 188 | 885 | 499 | | | | | | | 1.000 | 6.06 | 6.06 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – half preheat – ISO ign data – test 4** | Ignition Time | 386 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – half preheat – ISO ign data – test 5** | Ignition Time | 389 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | 392 | 6 | | | | | | | 0.721 | 18.76 | -6.82 | |
| 100 | 401 | 15 | 1210 | 300 | 488354 | 1464100 | 121250 | 0.0008 | 0.729 | 16.53 | 12.05 | 35.814 |
| 110 | 417 | 31 | 1255 | 330 | 525659 | 1575025 | 138410 | 0.0006 | 0.743 | 14.65 | 10.89 | 42.514 |
| 120 | 437 | 51 | 1317 | 360 | 579227 | 1734489 | 158500 | 0.0004 | 0.761 | 13.12 | 9.99 | 48.094 |
| 130 | 463 | 77 | 1400 | 390 | 655338 | 1960000 | 182630 | 0.0003 | 0.783 | 11.59 | 9.08 | 56.409 |
| 140 | 500 | 114 | 1510 | 420 | 763578 | 2280100 | 212240 | 0.0002 | 0.814 | 10.50 | 8.54 | 64.960 |
| 150 | 547 | 161 | 1648 | 450 | 910410 | 2715904 | 248210 | 0.0002 | 0.851 | 9.40 | 8.00 | 71.120 |
| 160 | 601 | 215 | 1795 | 480 | 1079019 | 3222025 | 288200 | 0.0002 | 0.892 | 8.39 | 7.49 | 70.786 |
| 170 | 647 | 261 | 1986 | 510 | 1324454 | 3944196 | 338990 | 0.0001 | 0.926 | 7.48 | 6.93 | 84.240 |
| 180 | 738 | 352 | 2203 | 540 | 1632377 | 4853209 | 398250 | 0.0001 | 0.989 | 6.57 | 6.50 | 92.530 |
| 190 | 818 | 432 | 2461 | 565 | 2032793 | 6056521 | 464735 | 0.0001 | 1.000 | 5.93 | 5.93 | 105.792 |
| 195 | 905 | 519 | | | | | | | 1.000 | 5.61 | 5.61 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | 396 | 7 | | | | | | | 0.724 | 18.76 | 13.59 | #DIV/0! |
| 100 | 401 | 12 | 1209 | 300 | 487361 | 1461681 | 121060 | 0.0012 | 0.729 | 16.53 | 12.05 | 28.940 |
| 110 | 412 | 23 | 1242 | 330 | 514586 | 1542564 | 136900 | 0.0007 | 0.739 | 14.65 | 10.83 | 37.702 |
| 120 | 429 | 40 | 1300 | 360 | 564466 | 1690000 | 156470 | 0.0004 | 0.754 | 13.12 | 9.89 | 49.091 |
| 130 | 459 | 70 | 1377 | 390 | 633843 | 1896129 | 179610 | 0.0003 | 0.780 | 11.59 | 9.04 | 54.772 |
| 140 | 489 | 100 | 1479 | 420 | 731763 | 2187441 | 207780 | 0.0003 | 0.805 | 10.50 | 8.45 | 60.277 |
| 150 | 531 | 142 | 1612 | 450 | 871546 | 2598544 | 242830 | 0.0002 | 0.839 | 9.40 | 7.88 | 72.169 |
| 160 | 592 | 203 | 1774 | 480 | 1056226 | 3147076 | 285040 | 0.0002 | 0.886 | 8.39 | 7.43 | 77.463 |
| 170 | 651 | 262 | 1953 | 510 | 1278365 | 3814209 | 333190 | 0.0002 | 0.929 | 7.48 | 6.95 | 76.811 |
| 180 | 710 | 321 | | | | | | | 0.970 | 6.57 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – half preheat – ISO ign data – test 6** | Ignition Time | 387 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | 389 | -371 | | | | | | | 0.718 | 20.99 | 15.07 | |
| 90 | 395 | -365 | 1186 | 270 | 468950 | 1406596 | 106870 | 0.0015 | 0.723 | 18.76 | 13.57 | 25.520 |
| 100 | 402 | -358 | 1215 | 300 | 492353 | 1476225 | 121730 | 0.0008 | 0.730 | 16.53 | 12.07 | 34.766 |
| 110 | 418 | -342 | 1261 | 330 | 530809 | 1590121 | 139100 | 0.0005 | 0.744 | 14.65 | 10.91 | 44.395 |
| 120 | 441 | -319 | 1332 | 360 | 592934 | 1774224 | 160390 | 0.0004 | 0.764 | 13.12 | 10.03 | 52.674 |
| 130 | 473 | -287 | 1424 | 390 | 678310 | 2027776 | 185810 | 0.0003 | 0.792 | 11.59 | 9.18 | 58.788 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 | | 510 | -250 | 1536 | 420 | 789638 | 2359296 | 215840 | 0.0002 | 0.822 | 10.50 | 8.63 | 63.305 |
| 150 | | 553 | -207 | 1672 | 450 | 936790 | 2795584 | 251790 | 0.0002 | 0.856 | 9.40 | 8.05 | 70.558 |
| 160 | | 609 | -151 | 1835 | 480 | 1129619 | 3367225 | 294800 | 0.0002 | 0.898 | 8.39 | 7.54 | 77.517 |
| 170 | | 673 | -87 | 2015 | 507 | 1361099 | 4060225 | 341591 | 0.0001 | 0.944 | 7.48 | 7.06 | 85.339 |
| 177 | | 733 | -27 | | | | | | | 0.986 | 6.84 | 6.74 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – full preheat – test 1** | Ignition Time | 760 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | 778 | 18 | | | | | | | 1.00 | 18.76 | | |
| 100 | 785 | 25 | 2352 | 300 | 1844030 | 5531904 | 235310 | 0.0018 | 1.00 | 16.53 | 16.53 | 23.741 |
| 110 | 789 | 29 | 2374 | 330 | 1878746 | 5635876 | 261290 | 0.0012 | 1.00 | 14.65 | 14.65 | 28.363 |
| 120 | 800 | 40 | 2415 | 360 | 1944797 | 5832225 | 290170 | 0.0005 | 1.00 | 13.12 | 13.12 | 44.174 |
| 130 | 826 | 66 | 2482 | 390 | 2055012 | 6160324 | 323220 | 0.0004 | 1.00 | 11.59 | 11.59 | 52.960 |
| 140 | 856 | 96 | 2579 | 420 | 2219621 | 6651241 | 361770 | 0.0003 | 1.00 | 10.50 | 10.50 | 59.820 |
| 150 | 897 | 137 | 2725 | 450 | 2482129 | 7425625 | 409910 | 0.0002 | 1.00 | 9.40 | 9.40 | 77.240 |
| 160 | 972 | 212 | 2912 | 480 | 2837242 | 8479744 | 467380 | 0.0001 | 1.00 | 8.39 | 8.39 | 85.451 |
| 170 | 1043 | 283 | 3089 | 502 | 3186109 | 9541921 | 517558 | 0.0001 | 1.00 | 7.48 | 7.48 | 90.661 |
| 172 | 1074 | 314 | | | | | | | 1.00 - | 7.30 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – full preheat – test 2** | Ignition Time | 760s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 791 | 31 | | | | | | | 1.000 | 16.53 | | |
| 110 | 796 | 36 | 2394 | 330 | 1910546 | 5731236 | 263500 | 0.0012 | 1.000 | 14.65 | 14.65 | 28.940 |
| 120 | 807 | 47 | 2426 | 360 | 1962194 | 5885476 | 291390 | 0.0007 | 1.000 | 13.12 | 13.12 | 36.952 |
| 130 | 823 | 63 | 2481 | 390 | 2052779 | 6155361 | 322970 | 0.0004 | 1.000 | 11.59 | 11.59 | 47.482 |
| 140 | 851 | 91 | 2563 | 420 | 2191851 | 6568969 | 359480 | 0.0003 | 1.000 | 10.50 | 10.50 | 57.665 |
| 150 | 889 | 129 | 2665 | 450 | 2370147 | 7102225 | 400490 | 0.0003 | 1.000 | 9.40 | 9.40 | 60.835 |
| 160 | 925 | 165 | 2804 | 480 | 2626046 | 7862416 | 449650 | 0.0002 | 1.000 | 8.39 | 8.39 | 72.033 |
| 170 | 990 | 230 | 2988 | 510 | 2987054 | 8928144 | 509440 | 0.0001 | 1.000 | 7.48 | 7.48 | 86.235 |
| 180 | 1073 | 313 | | | | | | | 1.000 | 6.57 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – full preheat – test 3** | Ignition Time | 760 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | 784 | 24 | | | | | | | 1.000 | 18.76 | | |
| 100 | 788 | 28 | 2365 | 300 | 1864449 | 5593225 | 236590 | 0.0022 | 1.000 | 16.53 | 16.53 | 21.257 |
| 110 | 793 | 33 | 2387 | 330 | 1899429 | 5697769 | 262750 | 0.0010 | 1.000 | 14.65 | 14.65 | 30.972 |
| 120 | 806 | 46 | 2423 | 360 | 1957461 | 5870929 | 291070 | 0.0006 | 1.000 | 13.12 | 13.12 | 39.540 |
| 130 | 824 | 64 | 2475 | 390 | 2042637 | 6125625 | 322140 | 0.0005 | 1.000 | 11.59 | 11.59 | 44.202 |
| 140 | 845 | 85 | 2554 | 420 | 2176226 | 6522916 | 358170 | 0.0003 | 1.000 | 10.50 | 10.50 | 56.113 |
| 150 | 885 | 125 | 2735 | 450 | 2507275 | 7480225 | 411850 | 0.0001 | 1.000 | 9.40 | 9.40 | 93.095 |
| 160 | 1005 | 245 | 2929 | 475 | 2872771 | 8579041 | 464985 | 0.0001 | 1.000 | 8.39 | 8.39 | 103.304 |
| 165 | 1039 | 279 | | | | | | | 1.000 | 7.94 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – full preheat – test 4** | Ignition Time | 771 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – full preheat – test 5** | Ignition Time | 760 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | 773 | 13 | | | | | | | 1.000 | 18.76 | | |
| 100 | 776 | 16 | 2329 | 300 | 1808105 | 5424241 | 232970 | 0.0028 | 1.000 | 16.53 | 16.53 | 18.772 |
| 110 | 780 | 20 | 2351 | 330 | 1842601 | 5527201 | 258800 | 0.0009 | 1.000 | 14.65 | 14.65 | 32.498 |
| 120 | 795 | 35 | 2294 | 360 | 1757386 | 5262436 | 274670 | -0.0002 | 1.000 | 13.12 | 13.12 | #NUM! |
| 130 | 719 | -41 | 2368 | 390 | 1878302 | 5607424 | 308430 | 0.0001 | 0.976 | 11.59 | 11.32 | 124.606 |
| 140 | 854 | 94 | 2464 | 420 | 2040158 | 6071296 | 346680 | 0.0001 | 1.000 | 10.50 | 10.50 | 97.625 |
| 150 | 989 | 229 | 2950 | 450 | 2902286 | 8702500 | 443030 | 0.0004 | 1.000 | 9.40 | 9.40 | 52.353 |
| 160 | 1007 | 247 | | | | | | | 1.000 | 8.39 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 891 | 131 | 2698 | 450 | 2431406 | 7279204 | 405690 | 0.0002 | 1.000 | 9.40 | 9.40 | 71.100 |
| 160 | 953 | 193 | 2857 | 479 | 2728259 | 8162449 | 457327 | 0.0002 | 1.000 | 8.39 | 8.39 | 80.124 |
| 169 | 1013 | 253 | | | | | | | | 7.57 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pynefloor particle board – full preheat – test 6** | Ignition Time | 760 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | 772 | 12 | | | | | | | 1.000 | 18.76 | | |
| 100 | 779 | 19 | 2339 | 300 | 1823769 | 5470921 | 234060 | 0.0012 | 1.000 | 16.53 | 16.53 | 28.358 |
| 110 | 788 | 28 | 2379 | 330 | 1887129 | 5659641 | 262020 | 0.0006 | 1.000 | 14.65 | 14.65 | 41.996 |
| 120 | 812 | 52 | 2438 | 360 | 1982532 | 5943844 | 293060 | 0.0004 | 1.000 | 13.12 | 13.12 | 50.013 |
| 130 | 838 | 78 | 2520 | 390 | 2118488 | 6350400 | 328180 | 0.0003 | 1.000 | 11.59 | 11.59 | 53.948 |
| 140 | 870 | 110 | 2628 | 420 | 2305544 | 6906384 | 368740 | 0.0002 | 1.000 | 10.50 | 10.50 | 64.543 |
| 150 | 920 | 160 | 2758 | 450 | 2540324 | 7606564 | 414680 | 0.0002 | 1.000 | 9.40 | 9.40 | 70.005 |
| 160 | 968 | 208 | 2969 | 479 | 2951985 | 8814961 | 475569 | 0.0001 | 1.000 | 8.39 | 8.39 | 94.857 |
| 169 | 1081 | 321 | | | | | | | 1.000 | 7.57 | | |

**Superflake particle board**

| Flame Front Position x | Time to position t | time from ignition | Σt | Σx | $\Sigma(t^2)$ | $\Sigma(t)^2$ | Σ(t.x) | V | F(t) | q" | q"*F(t) | $1/\sqrt{V}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake PB – low preheat – ISO ign data – test 1** | Ignition Time | 82 | | | | | | m/s | | kW/m$^2$ | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | 33.82 | | |
| 20 | | | | | | | | | | 32.76 | | |
| 30 | 89 | 7 | | | | | | | | 31.96 | | |
| 40 | 95 | 13 | 288 | 120 | 27762 | 82944 | 11670 | 0.0013 | 0.319 | 29.56 | 9.42 | 27.568 |
| 50 | 104 | 22 | 318 | 150 | 34002 | 101124 | 16140 | 0.0008 | 0.334 | 27.16 | 9.06 | 35.000 |
| 60 | 119 | 37 | 359 | 180 | 43473 | 128881 | 21860 | 0.0006 | 0.357 | 24.97 | 8.91 | 40.026 |
| 70 | 136 | 54 | 430 | 210 | 63282 | 184900 | 30660 | 0.0003 | 0.381 | 22.98 | 8.76 | 54.259 |
| 80 | 175 | 93 | 493 | 240 | 82245 | 243049 | 39900 | 0.0004 | 0.433 | 20.99 | 9.08 | 51.682 |
| 90 | 182 | 100 | 571 | 270 | 109545 | 326041 | 51780 | 0.0005 | 0.441 | 18.76 | 8.28 | 47.086 |
| 100 | 214 | 132 | 642 | 300 | 139436 | 412164 | 64840 | 0.0003 | 0.479 | 16.53 | 7.91 | 56.569 |
| 110 | 246 | 164 | 757 | 330 | 194521 | 573049 | 84100 | 0.0002 | 0.513 | 14.65 | 7.52 | 64.981 |
| 120 | 297 | 215 | 890 | 359 | 269134 | 792100 | 107463 | 0.0002 | 0.564 | 13.12 | 7.40 | 72.904 |
| 129 | 347 | 265 | | | | | | | 0.609 | 11.75 | 7.16 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *$\Sigma(t^2)$* | *$\Sigma(t)^2$* | *Σ(t.x)* | *$V_f$* | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake PB – low preheat – ISO ign data – test 2** | Ignition Time | 82 | | | | | | m/s | | kW/m$^2$ | | $(m/s)^{-0.5}$ |
| | | | | | | | | | | 34.88 | | |
| 10 | | | | | | | | | | 33.82 | | |
| 20 | | | | | | | | | | 32.76 | | |
| 30 | 82 | | | | | | | | | 31.96 | | |
| 40 | 93 | 11 | | | | | | | | 29.56 | | |
| 50 | 100 | 18 | 309 | 150 | 32105 | 95481 | 15680 | 0.0008 | 0.327 | 27.16 | 8.88 | 34.766 |
| 60 | 116 | 34 | 343 | 180 | 39585 | 117649 | 20850 | 0.0007 | 0.352 | 24.97 | 8.80 | 36.952 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 127 | 45 | 393 | 210 | 52085 | 154449 | 27850 | 0.0006 | 0.369 | 22.98 | 8.47 | 42.078 |
| 80 | 150 | 68 | 447 | 240 | 67529 | 199809 | 36190 | 0.0005 | 0.401 | 20.99 | 8.41 | 46.406 |
| 90 | 170 | 88 | 518 | 270 | 90604 | 268324 | 47100 | 0.0004 | 0.426 | 18.76 | 8.00 | 49.216 |
| 100 | 198 | 116 | 597 | 300 | 120545 | 356409 | 60290 | 0.0003 | 0.460 | 16.53 | 7.61 | 54.337 |
| 110 | 229 | 147 | 707 | 330 | 170045 | 499849 | 78590 | 0.0002 | 0.495 | 14.65 | 7.25 | 64.663 |
| 120 | 280 | 198 | 840 | 360 | 240402 | 705600 | 101820 | 0.0002 | 0.547 | 13.12 | 7.18 | 71.414 |
| 130 | 331 | 249 | 994 | 390 | 334650 | 988036 | 130250 | 0.0002 | 0.595 | 11.59 | 6.90 | 71.765 |
| 140 | 383 | 301 | 1177 | 420 | 470619 | 1385329 | 166100 | 0.0001 | 0.640 | 10.50 | 6.72 | 81.847 |
| 150 | 463 | 381 | 1424 | 450 | 695142 | 2027776 | 215550 | 0.0001 | 0.704 | 9.40 | 6.62 | 99.271 |
| 160 | 578 | 496 | 1748 | 320 | 548453 | 3055504 | 161930 | 0.0001 | 0.786 | 8.39 | 6.60 | 138.446 |
| 167 | 707 | 625 | | | | | | | 0.870 | 7.76 | 6.74 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e . F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake PB – low preheat – ISO ign data – test 3** | Ignition Time | 83 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | 33.82 | | |
| 20 | | | | | | | | | | 32.76 | | |
| 30 | 83 | 0 | | | | | | | | 31.96 | | |
| 40 | 91 | 8 | | | | | | | | 29.56 | | |
| 50 | 97 | 14 | 302 | 150 | 30686 | 91204 | 15330 | 0.0008 | 0.322 | 27.16 | 8.75 | 35.181 |
| 60 | 114 | 31 | 342 | 180 | 39566 | 116964 | 20860 | 0.0006 | 0.349 | 24.97 | 8.72 | 41.231 |
| 70 | 131 | 48 | 394 | 210 | 52358 | 155236 | 27930 | 0.0006 | 0.374 | 22.98 | 8.60 | 41.839 |
| 80 | 149 | 66 | 455 | 240 | 69987 | 207025 | 36840 | 0.0004 | 0.399 | 20.99 | 8.38 | 47.162 |
| 90 | 175 | 92 | 530 | 270 | 95262 | 280900 | 48270 | 0.0003 | 0.433 | 18.76 | 8.12 | 53.454 |
| 100 | 206 | 123 | 629 | 300 | 134565 | 395641 | 63630 | 0.0003 | 0.469 | 16.53 | 7.76 | 60.643 |
| 110 | 248 | 165 | 740 | 330 | 185736 | 547600 | 82200 | 0.0002 | 0.515 | 14.65 | 7.55 | 63.272 |
| 120 | 286 | 203 | 869 | 360 | 255525 | 755161 | 105150 | 0.0002 | 0.553 | 13.12 | 7.26 | 66.130 |
| 130 | 335 | 252 | 1053 | 390 | 380645 | 1108809 | 138350 | 0.0001 | 0.599 | 11.59 | 6.94 | 86.966 |
| 140 | 432 | 349 | 1257 | 420 | 538949 | 1580049 | 177530 | 0.0001 | 0.680 | 10.50 | 7.14 | 88.958 |
| 150 | 490 | 407 | 1507 | 442 | 768949 | 2271049 | 222900 | 0.0001 | 0.724 | 9.40 | 6.81 | 117.204 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 152 | 585 | 502 | | | | | | | 0.791 | 9.20 | 7.28 | |
| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
| **RIFT – Superflake PB – low preheat – ISO ign data – test 4** | Ignition Time | 82 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | 33.82 | | |
| 20 | | | | | | | | | | 32.76 | | |
| 30 | 82 | 0 | | | | | | | | 31.96 | | |
| 40 | 91 | 9 | 272 | 120 | 24806 | 73984 | 11050 | 0.0012 | 0.312 | 29.56 | 9.22 | 29.172 |
| 50 | 99 | 17 | 300 | 150 | 30182 | 90000 | 15190 | 0.0010 | 0.325 | 27.16 | 8.84 | 30.950 |
| 60 | 110 | 28 | 335 | 180 | 37777 | 112225 | 20370 | 0.0007 | 0.343 | 24.97 | 8.56 | 36.952 |
| 70 | 126 | 44 | 381 | 210 | 49001 | 145161 | 27020 | 0.0006 | 0.367 | 22.98 | 8.44 | 41.884 |
| 80 | 145 | 63 | 459 | 240 | 72245 | 210681 | 37340 | 0.0003 | 0.394 | 20.99 | 8.27 | 57.051 |
| 90 | 188 | 106 | 528 | 270 | 94394 | 278784 | 48020 | 0.0003 | 0.448 | 18.76 | 8.41 | 54.148 |
| 100 | 195 | 113 | 616 | 300 | 127658 | 379456 | 62050 | 0.0004 | 0.457 | 16.53 | 7.55 | 51.048 |
| 110 | 233 | 151 | 695 | 330 | 163603 | 483025 | 77170 | 0.0003 | 0.499 | 14.65 | 7.32 | 60.031 |
| 120 | 267 | 185 | 825 | 360 | 231203 | 680625 | 99920 | 0.0002 | 0.534 | 13.12 | 7.01 | 68.588 |
| 130 | 325 | 243 | 1057 | 390 | 393139 | 1117249 | 139390 | 0.0001 | 0.590 | 11.59 | 6.84 | 102.303 |
| 140 | 465 | 383 | 1309 | 420 | 591211 | 1713481 | 185200 | 0.0001 | 0.705 | 10.50 | 7.40 | 101.663 |
| 150 | 519 | 437 | 1579 | 443 | 839611 | 2493241 | 233985 | 0.0001 | 0.745 | 9.40 | 7.00 | 102.038 |
| 153 | 595 | 513 | | | | | | | 0.798 | 9.10 | 7.26 | |
| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e.F(t)$ | $1/\sqrt{V_f}$ |
| **RIFT – Superflake PB – low preheat – ISO ign data – test 5** | Ignition Time | 82 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | 33.82 | | |
| 20 | 82 | | | | | | | | | 32.76 | | |
| 30 | 88 | 6 | 262 | 90 | 22932 | 68644 | 7960 | 0.0020 | 0.307 | 31.96 | 9.81 | 22.509 |
| 40 | 92 | 10 | 282 | 120 | 26612 | 79524 | 11420 | 0.0013 | 0.314 | 29.56 | 9.27 | 27.255 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 102 | 20 | 311 | 150 | 32557 | 96721 | 15800 | 0.0008 | 0.330 | 27.16 | 8.97 | 35.590 |
| 60 | 117 | 35 | 355 | 180 | 42589 | 126025 | 21640 | 0.0006 | 0.354 | 24.97 | 8.83 | 41.326 |
| 70 | 136 | 54 | 409 | 210 | 56521 | 167281 | 29020 | 0.0005 | 0.381 | 22.98 | 8.76 | 44.164 |
| 80 | 156 | 74 | 475 | 240 | 76321 | 225625 | 38470 | 0.0004 | 0.409 | 20.99 | 8.57 | 48.656 |
| 90 | 183 | 101 | 559 | 270 | 106225 | 312481 | 50950 | 0.0003 | 0.442 | 18.76 | 8.30 | 56.798 |
| 100 | 220 | 138 | 652 | 300 | 143890 | 425104 | 65860 | 0.0003 | 0.485 | 16.53 | 8.02 | 57.586 |
| 110 | 249 | 167 | 772 | 330 | 202210 | 595984 | 85750 | 0.0002 | 0.516 | 14.65 | 7.56 | 65.387 |
| 120 | 303 | 221 | 907 | 360 | 279835 | 822649 | 109900 | 0.0002 | 0.569 | 13.12 | 7.47 | 72.805 |
| 130 | 355 | 273 | 1079 | 390 | 395075 | 1164241 | 141450 | 0.0002 | 0.616 | 11.59 | 7.14 | 76.991 |
| 140 | 421 | 339 | 1285 | 420 | 562347 | 1651225 | 181440 | 0.0001 | 0.671 | 10.50 | 7.04 | 88.048 |
| 150 | 509 | 427 | 1486 | 443 | 745458 | 2208196 | 220358 | 0.0001 | 0.738 | 9.40 | 6.94 | 100.750 |
| 153 | 556 | 474 | | | | | | | 0.771 | 9.10 | 7.02 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake PB – low preheat – ISO ign data – test 6** | Ignition Time | 82 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | 33.82 | | |
| 20 | | | | | | | | | | 32.76 | | |
| 30 | 82 | 0 | 175 | 90 | 15373 | 30625 | 6180 | 0.0002 | 0.296 | 31.96 | 9.47 | 74.521 |
| 40 | 93 | 11 | 283 | 120 | 27037 | 80089 | 11580 | 0.0008 | 0.315 | 29.56 | 9.32 | 36.197 |
| 50 | 108 | 26 | 324 | 150 | 35442 | 104976 | 16500 | 0.0007 | 0.340 | 27.16 | 9.23 | 38.730 |
| 60 | 123 | 41 | 368 | 180 | 45562 | 135424 | 22370 | 0.0007 | 0.363 | 24.97 | 9.06 | 38.086 |
| 70 | 137 | 55 | 422 | 210 | 60142 | 178084 | 29930 | 0.0005 | 0.383 | 22.98 | 8.80 | 44.740 |
| 80 | 162 | 80 | 492 | 240 | 82262 | 242064 | 39920 | 0.0004 | 0.416 | 20.99 | 8.74 | 53.016 |
| 90 | 193 | 111 | 582 | 270 | 115022 | 338724 | 53030 | 0.0003 | 0.454 | 18.76 | 8.52 | 57.029 |
| 100 | 227 | 145 | 689 | 300 | 161139 | 474721 | 69660 | 0.0003 | 0.493 | 16.53 | 8.15 | 61.758 |
| 110 | 269 | 187 | 816 | 330 | 226290 | 665856 | 90690 | 0.0002 | 0.536 | 14.65 | 7.86 | 68.297 |
| 120 | 320 | 238 | 939 | 360 | 297261 | 881721 | 113490 | 0.0002 | 0.585 | 13.12 | 7.68 | 64.349 |
| 130 | 350 | 268 | | | | | | | 0.612 | 11.59 | 7.09 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake Particle Board Full preheat – test 1** | Ignition Time | 699 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 706 | 7 | | | | | | | 0.869 | 16.53 | | |
| 110 | 711 | 12 | 2139 | 330 | 1525241 | 4575321 | 235450 | 0.0012 | 0.872 | 14.65 | 12.78 | 28.940 |
| 120 | 722 | 23 | 2175 | 360 | 1577369 | 4730625 | 261310 | 0.0006 | 0.879 | 13.12 | 11.53 | 39.919 |
| 130 | 742 | 43 | 2235 | 390 | 1666289 | 4995225 | 291040 | 0.0004 | 1.000 | 11.59 | 11.59 | 49.775 |
| 140 | 771 | 72 | 2322 | 420 | 1799486 | 5391684 | 325750 | 0.0003 | 1.000 | 10.50 | 10.50 | 58.053 |
| 150 | 809 | 110 | 2432 | 450 | 1974826 | 5914624 | 365610 | 0.0002 | 1.000 | 9.40 | 9.40 | 63.680 |
| 160 | 852 | 153 | 2587 | 478 | 2237861 | 6692569 | 413238 | 0.0001 | 1.000 | 8.39 | 8.39 | 81.964 |
| 168 | 926 | 227 | | | | | | | 1.000 | 7.66 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake Particle Board Full preheat – test 2** | Ignition Time | 755 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake Particle Board Full preheat – test 3** | Ignition Time | 755 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 763 | 8 | | | | | | | | 16.53 | | |
| 110 | 771 | 16 | 2318 | 330 | 1791266 | 5373124 | 255190 | 0.0009 | 1.000 | 14.65 | 14.65 | 32.708 |
| 120 | 784 | 29 | 2357 | 360 | 1852301 | 5555449 | 283150 | 0.0006 | 1.000 | 13.12 | 13.12 | 39.540 |
| 130 | 802 | 47 | 2420 | 390 | 1953416 | 5856400 | 315100 | 0.0004 | 1.000 | 11.59 | 11.59 | 50.649 |
| 140 | 834 | 79 | 2514 | 420 | 2109644 | 6320196 | 352720 | 0.0003 | 1.000 | 10.50 | 10.50 | 61.900 |
| 150 | 878 | 123 | 2648 | 450 | 2342536 | 7011904 | 398220 | 0.0002 | 1.000 | 9.40 | 9.40 | 71.638 |
| 160 | 936 | 181 | 2814 | 320 | 1646980 | 7918596 | 281460 | 0.0000 | 1.000 | 8.39 | 8.39 | 230.386 |
| 170 | 1000 | 245 | 2990 | 505 | 2987012 | 8940100 | 504210 | 0.0001 | 1.000 | 7.48 | 7.48 | 88.385 |
| 175 | 1054 | 299 | | | | | | | 1.000 | 7.02 | | |
| 100 | 761 | 6 | | | | | | | 1.000 | 16.53 | | |
| 110 | 769 | 14 | 2312 | 330 | 1782006 | 5345344 | 254530 | 0.0009 | 1.000 | 14.65 | 14.65 | 32.708 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 782 | 27 | 2351 | 360 | 1842885 | 5527201 | 282430 | 0.0006 | 1.000 | 13.12 | 13.12 | 39.540 |
| 130 | 800 | 45 | 2409 | 390 | 1935453 | 5803281 | 313620 | 0.0004 | 1.000 | 11.59 | 11.59 | 47.749 |
| 140 | 827 | 72 | 2493 | 420 | 2073885 | 6215049 | 349680 | 0.0003 | 1.000 | 10.50 | 10.50 | 57.761 |
| 150 | 866 | 111 | 2595 | 450 | 2247489 | 6734025 | 390000 | 0.0003 | 1.000 | 9.40 | 9.40 | 61.254 |
| 160 | 902 | 147 | 2783 | 479 | 2593785 | 7745089 | 445755 | 0.0001 | 1.000 | 8.39 | 8.39 | 92.835 |
| 169 | 1015 | 260 | | | | | | | 1.000 | 7.57 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake Particle Board Full preheat – test4** | Ignition Time | 755 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 762 | 7 | | | | | | | 1.000 | 16.53 | | |
| 110 | 769 | 14 | 2314 | 330 | 1785094 | 5354596 | 254750 | 0.0009 | 1.000 | 14.65 | 14.65 | 32.998 |
| 120 | 783 | 28 | 2368 | 360 | 1870306 | 5607424 | 284630 | 0.0004 | 1.000 | 13.12 | 13.12 | 49.780 |
| 130 | 816 | 61 | 2451 | 390 | 2004849 | 6007401 | 319320 | 0.0003 | 1.000 | 11.59 | 11.59 | 58.755 |
| 140 | 852 | 97 | 2565 | 420 | 2196369 | 6579225 | 359910 | 0.0002 | 1.000 | 10.50 | 10.50 | 63.770 |
| 150 | 897 | 142 | 2714 | 448 | 2461738 | 7365796 | 406300 | 0.0002 | 1.000 | 9.40 | 9.40 | 80.080 |
| 158 | 965 | 210 | | | | | | | 1.000 | 8.60 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake Particle Board Full preheat – test 5** | Ignition Time | 756 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 765 | 9 | 1535 | 300 | 1178125 | 2356225 | 161200 | 0.0000 | 1.000 | 16.53 | 16.53 | 225.837 |
| 110 | 770 | 14 | 2321 | 330 | 1795921 | 5387041 | 255520 | 0.0009 | 1.000 | 14.65 | 14.65 | 33.853 |
| 120 | 786 | 30 | 2362 | 360 | 1860332 | 5579044 | 283800 | 0.0006 | 1.000 | 13.12 | 13.12 | 42.514 |
| 130 | 806 | 50 | 2424 | 390 | 1959656 | 5875776 | 315580 | 0.0004 | 1.000 | 11.59 | 11.59 | 48.094 |
| 140 | 832 | 76 | 2507 | 420 | 2097021 | 6285049 | 351610 | 0.0003 | 1.000 | 10.50 | 10.50 | 56.409 |
| 150 | 869 | 113 | 2619 | 450 | 2290109 | 6859161 | 393710 | 0.0002 | 1.000 | 9.40 | 9.40 | 65.787 |
| 160 | 918 | 162 | 2770 | 480 | 2564174 | 7672900 | 444340 | 0.0002 | 1.000 | 8.39 | 8.39 | 75.746 |
| 170 | 983 | 227 | 2933 | 505 | 2874037 | 8602489 | 494590 | 0.0001 | 1.000 | 7.48 | 7.48 | 86.790 |
| 175 | 1032 | 276 | | | | | | | 1.000 | 7.02 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Superflake Particle Board Full preheat – test 6** | Ignition Time | 755 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 765 | 10 | | | | | | | 1.000 | 16.53 | | |
| 110 | 771 | 16 | 2320 | 330 | 1794322 | 5382400 | 255390 | 0.0010 | 1.000 | 14.65 | 14.65 | 31.512 |
| 120 | 784 | 29 | 2358 | 360 | 1853906 | 5560164 | 283280 | 0.0006 | 1.000 | 13.12 | 13.12 | 40.234 |
| 130 | 803 | 48 | 2418 | 390 | 1950026 | 5846724 | 314810 | 0.0004 | 1.000 | 11.59 | 11.59 | 48.772 |
| 140 | 831 | 76 | 2501 | 420 | 2087059 | 6255001 | 350780 | 0.0003 | 1.000 | 10.50 | 10.50 | 56.716 |
| 150 | 867 | 112 | 2609 | 450 | 2272171 | 6806881 | 392150 | 0.0002 | 1.000 | 9.40 | 9.40 | 63.351 |
| 160 | 911 | 156 | 2763 | 480 | 2551835 | 7634169 | 443260 | 0.0002 | 1.000 | 8.39 | 8.39 | 77.635 |
| 170 | 985 | 230 | 2956 | 510 | 2923746 | 8737936 | 504010 | 0.0001 | 1.000 | 7.48 | 7.48 | 86.314 |
| 180 | 1060 | 305 | | | | | | | 1.000 | 6.57 | | |

**Radiata Pine**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Radiata Pine test 1** | Ignition Time | 635 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 225 | | | | | | | | | | | | |
| 250 | | | | | | | | | | | | |
| 275 | | | | | | | | | | | | |
| 300 | 653 | 18 | | | | | | | 1.000 | 16.50 | | |
| 325 | 656 | 21 | 1972 | 975 | 1296314 | 3888784 | 641150 | 0.0047 | 1.000 | 14.90 | 14.90 | 14.514 |
| 350 | 663 | 28 | 1997 | 1050 | 1329589 | 3988009 | 699500 | 0.0022 | 1.000 | 13.20 | 13.20 | 21.433 |
| 375 | 678 | 43 | 2038 | 1125 | 1385062 | 4153444 | 765100 | 0.0015 | 1.000 | 11.50 | 11.50 | 26.137 |
| 400 | 697 | 62 | 2094 | 1200 | 1462454 | 4384836 | 838625 | 0.0012 | 1.000 | 9.80 | 9.80 | 28.661 |
| 425 | 719 | 84 | 2168 | 1275 | 1568274 | 4700224 | 922775 | 0.0009 | 1.000 | 8.40 | 8.40 | 33.387 |
| 450 | 752 | 117 | 2261 | 1350 | 1706565 | 5112121 | 1019225 | 0.0007 | 1.000 | 6.90 | 6.90 | 37.714 |
| 475 | 790 | 155 | 2380 | 1425 | 1891848 | 5664400 | 1132650 | 0.0006 | 1.000 | 6.00 | 6.00 | 41.566 |
| 500 | 838 | 203 | 2493 | 1480 | 2074569 | 6215049 | 1231075 | 0.0004 | 1.000 | 5.00 | 5.00 | 49.143 |
| 505 | 865 | 230 | | | | | | | | 4.84 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Radiata Pine test 2** | Ignition Time | 639 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 225 | | | | | | | | | | | | |
| 250 | | | | | | | | | | | | |
| 275 | | | | | | | | | | | | |
| 300 | 657 | 18 | | | | | | | 1.000 | 16.50 | | |
| 325 | 669 | 30 | 2001 | 975 | 1334835 | 4004001 | 650775 | 0.0027 | 1.000 | 14.90 | 14.90 | 19.322 |
| 350 | 675 | 36 | 2039 | 1050 | 1386211 | 4157521 | 714300 | 0.0018 | 1.000 | 13.20 | 13.20 | 23.880 |
| 375 | 695 | 56 | 2089 | 1125 | 1455611 | 4363921 | 784475 | 0.0011 | 1.000 | 11.50 | 11.50 | 29.706 |
| 400 | 719 | 80 | 2163 | 1200 | 1560987 | 4678569 | 866550 | 0.0009 | 1.000 | 9.80 | 9.80 | 32.931 |
| 425 | 749 | 110 | 2262 | 1275 | 1708398 | 5116644 | 963225 | 0.0007 | 1.000 | 8.40 | 8.40 | 38.987 |
| 450 | 794 | 155 | 2383 | 1350 | 1897037 | 5678689 | 1074625 | 0.0005 | 1.000 | 6.90 | 6.90 | 42.662 |
| 475 | 840 | 201 | 2601 | 1425 | 2271125 | 6765201 | 1239800 | 0.0003 | 1.000 | 6.00 | 6.00 | 60.933 |
| 500 | 967 | 328 | | | | | | | 1.000 | 5.00 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Radiata Pine test 3** | Ignition Time | 655 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 225 | | | | | | | | | | | | |
| 250 | | | | | | | | | | | | |
| 275 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 300 | | | | | | | | | | | | |
| 325 | | | | | | | | | | | | |
| 350 | 675 | 20 | | | | | | | | 13.20 | | |
| 375 | 682 | 27 | 2051 | 1125 | 1402385 | 4206601 | 769600 | 0.0026 | 1.000 | 11.50 | 11.50 | 19.717 |
| 400 | 694 | 39 | 2090 | 1200 | 1456556 | 4368100 | 836800 | 0.0015 | 1.000 | 9.80 | 9.80 | 25.560 |
| 425 | 714 | 59 | 2147 | 1275 | 1537553 | 4609609 | 913600 | 0.0011 | 1.000 | 8.40 | 8.40 | 30.062 |
| 450 | 739 | 84 | 2228 | 1350 | 1656542 | 4963984 | 1004125 | 0.0008 | 1.000 | 6.90 | 6.90 | 35.117 |
| 475 | 775 | 120 | 2382 | 1425 | 1900170 | 5673924 | 1134675 | 0.0004 | 1.000 | 6.00 | 6.00 | 52.420 |
| 500 | 868 | 213 | 2608 | 1500 | 2285274 | 6801664 | 1308750 | 0.0003 | 1.000 | 5.00 | 5.00 | 61.649 |
| 525 | 965 | 310 | 2868 | 1564 | 2755874 | 8225424 | 1498490 | 0.0002 | 1.000 | 4.20 | 4.20 | 65.228 |
| 539 | 1035 | 380 | | | | | | | | 3.75 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $I/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pine- low preheat ISO ign data- test 1** | Ignition Time | 43 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 42 | 0 | | | | | | | 0.256 | 33.88 | | |
| 20 | 43 | 1 | 129 | 60 | 5549 | 16641 | 2600 | 0.0100 | 0.259 | 32.87 | 8.50 | 10.000 |
| 30 | 44 | 2 | 132 | 90 | 5810 | 17424 | 3980 | 0.0100 | 0.262 | 32.16 | 8.41 | 10.000 |
| 40 | 45 | 3 | 136 | 120 | 6170 | 18496 | 5470 | 0.0064 | 0.264 | 29.67 | 7.85 | 12.472 |
| 50 | 47 | 5 | 145 | 150 | 7043 | 21025 | 7330 | 0.0023 | 0.270 | 27.17 | 7.34 | 20.817 |
| 60 | 53 | 11 | 161 | 180 | 8739 | 25921 | 9800 | 0.0014 | 0.287 | 24.95 | 7.16 | 26.547 |
| 70 | 61 | 19 | 184 | 210 | 11430 | 33856 | 13050 | 0.0012 | 0.308 | 22.99 | 7.08 | 29.172 |
| 80 | 70 | 28 | 213 | 240 | 15345 | 45369 | 17250 | 0.0009 | 0.330 | 21.03 | 6.94 | 32.514 |
| 90 | 82 | 40 | 247 | 270 | 20649 | 61009 | 22480 | 0.0008 | 0.357 | 18.88 | 6.74 | 35.365 |
| 100 | 95 | 53 | 297 | 300 | 30149 | 88209 | 30080 | 0.0005 | 0.384 | 16.73 | 6.43 | 44.308 |
| 110 | 120 | 78 | 363 | 330 | 45329 | 131769 | 40460 | 0.0004 | 0.432 | 15.06 | 6.50 | 51.506 |
| 120 | 148 | 106 | 440 | 360 | 65888 | 193600 | 53320 | 0.0004 | 0.480 | 13.89 | 6.66 | 51.040 |
| 130 | 172 | 130 | 521 | 390 | 91889 | 271441 | 68260 | 0.0004 | 0.517 | 12.71 | 6.57 | 51.554 |
| 140 | 201 | 159 | 603 | 420 | 122885 | 363609 | 85000 | 0.0003 | 0.559 | 11.59 | 6.48 | 53.852 |
| 150 | 230 | 188 | 688 | 450 | 159350 | 473344 | 103760 | 0.0004 | 0.598 | 10.48 | 6.26 | 52.926 |
| 160 | 257 | 215 | 773 | 480 | 200745 | 597529 | 124240 | 0.0004 | 0.632 | 9.39 | 5.93 | 52.926 |
| 170 | 286 | 244 | 862 | 510 | 249606 | 743044 | 147160 | 0.0003 | 0.667 | 8.33 | 5.56 | 55.716 |
| 180 | 319 | 277 | 959 | 540 | 308873 | 919681 | 173300 | 0.0003 | 0.704 | 7.27 | 5.12 | 58.318 |
| 190 | 354 | 312 | 1079 | 570 | 391913 | 1164241 | 205880 | 0.0002 | 0.742 | 6.55 | 4.86 | 66.373 |
| 200 | 406 | 364 | | | | | | | 0.794 | 5.83 | 4.63 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine- low preheat ISO ign data- test 2** | Ignition Time | 42 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 43 | 0 | | | | | | | 0.259 | 33.88 | | |
| 20 | 44 | 1 | 133 | 60 | 5901 | 17689 | 2690 | 0.0064 | 0.262 | 32.87 | 8.60 | 12.472 |
| 30 | 46 | 3 | 139 | 90 | 6453 | 19321 | 4220 | 0.0039 | 0.267 | 32.16 | 8.60 | 15.916 |
| 40 | 49 | 6 | 148 | 120 | 7326 | 21904 | 5990 | 0.0028 | 0.276 | 29.67 | 8.19 | 18.772 |
| 50 | 53 | 10 | 161 | 150 | 8691 | 25921 | 8150 | 0.0020 | 0.287 | 27.17 | 7.80 | 22.509 |
| 60 | 59 | 16 | 180 | 180 | 10914 | 32400 | 10950 | 0.0013 | 0.303 | 24.95 | 7.56 | 27.568 |
| 70 | 68 | 25 | 203 | 210 | 13881 | 41209 | 14380 | 0.0012 | 0.325 | 22.99 | 7.48 | 29.172 |
| 80 | 76 | 33 | 230 | 240 | 17796 | 52900 | 18580 | 0.0011 | 0.344 | 21.03 | 7.23 | 30.062 |
| 90 | 86 | 43 | 258 | 270 | 22388 | 66564 | 23420 | 0.0010 | 0.366 | 18.88 | 6.90 | 31.623 |
| 100 | 96 | 53 | 294 | 300 | 29156 | 86436 | 29660 | 0.0008 | 0.386 | 16.73 | 6.46 | 36.374 |
| 110 | 112 | 69 | 335 | 330 | 37889 | 112225 | 37160 | 0.0006 | 0.417 | 15.06 | 6.28 | 39.377 |
| 120 | 127 | 84 | 387 | 360 | 50577 | 149769 | 46800 | 0.0006 | 0.444 | 13.89 | 6.17 | 42.622 |
| 130 | 148 | 105 | 445 | 390 | 66933 | 198025 | 58280 | 0.0005 | 0.480 | 12.71 | 6.10 | 46.372 |
| 140 | 170 | 127 | 517 | 420 | 90405 | 267289 | 72890 | 0.0004 | 0.514 | 11.59 | 5.96 | 50.656 |
| 150 | 199 | 156 | 601 | 450 | 122325 | 361201 | 90770 | 0.0003 | 0.556 | 10.48 | 5.83 | 55.716 |
| 160 | 232 | 189 | 697 | 480 | 164181 | 485809 | 112190 | 0.0003 | 0.601 | 9.39 | 5.64 | 57.881 |
| 170 | 266 | 223 | 808 | 504 | 220680 | 652864 | 136280 | 0.0002 | 0.643 | 8.33 | 5.36 | 75.541 |
| 174 | 310 | 267 | | | | | | | 0.694 | 7.91 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine- low preheat ISO ign data- test 3** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | 0.249 | 33.88 | | |
| 20 | 41 | 1 | 123 | 60 | 5045 | 15129 | 2480 | 0.0100 | 0.252 | 32.87 | 8.30 | 10.000 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 42 | 2 | 126 | 90 | 5294 | 15876 | 3800 | 0.0100 | 0.256 | 32.16 | 8.22 | 10.000 |
| 40 | 43 | 3 | 133 | 120 | 5917 | 17689 | 5380 | 0.0029 | 0.259 | 29.67 | 7.67 | 18.559 |
| 50 | 48 | 8 | 145 | 150 | 7069 | 21025 | 7360 | 0.0018 | 0.273 | 27.17 | 7.42 | 23.484 |
| 60 | 54 | 14 | 163 | 180 | 8941 | 26569 | 9910 | 0.0015 | 0.290 | 24.95 | 7.23 | 25.520 |
| 70 | 61 | 21 | 186 | 210 | 11678 | 34596 | 13190 | 0.0012 | 0.308 | 22.99 | 7.08 | 29.306 |
| 80 | 71 | 31 | 220 | 240 | 16506 | 48400 | 17870 | 0.0007 | 0.332 | 21.03 | 6.99 | 37.152 |
| 90 | 88 | 48 | 259 | 270 | 22785 | 67081 | 23600 | 0.0007 | 0.370 | 18.88 | 6.98 | 38.267 |
| 100 | 100 | 60 | 299 | 300 | 30065 | 89401 | 30130 | 0.0009 | 0.394 | 16.73 | 6.59 | 33.922 |
| 110 | 111 | 71 | 337 | 330 | 38197 | 113569 | 37330 | 0.0008 | 0.415 | 15.06 | 6.26 | 36.197 |
| 120 | 126 | 86 | 411 | 360 | 58473 | 168921 | 49950 | 0.0003 | 0.443 | 13.89 | 6.14 | 58.635 |
| 130 | 174 | 134 | 484 | 390 | 80008 | 234256 | 63500 | 0.0003 | 0.520 | 12.71 | 6.61 | 57.576 |
| 140 | 184 | 144 | 570 | 420 | 109076 | 324900 | 80180 | 0.0005 | 0.535 | 11.59 | 6.20 | 45.190 |
| 150 | 212 | 172 | 636 | 450 | 136400 | 404496 | 95960 | 0.0004 | 0.574 | 10.48 | 6.01 | 52.915 |
| 160 | 240 | 200 | 726 | 480 | 177620 | 527076 | 116780 | 0.0003 | 0.611 | 9.39 | 5.73 | 55.764 |
| 170 | 274 | 234 | 833 | 505 | 234437 | 693889 | 140805 | 0.0002 | 0.653 | 8.33 | 5.44 | 73.376 |
| 175 | 319 | 279 | | | | | | | 0.704 | 7.80 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $I/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Pine- low preheat ISO ign data- test 4** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | 0.249 | 33.88 | | |
| 20 | 41 | 1 | 123 | 60 | 5045 | 15129 | 2480 | 0.0100 | 0.252 | 32.87 | 8.30 | 10.000 |
| 30 | 42 | 2 | 129 | 90 | 5561 | 16641 | 3920 | 0.0036 | 0.256 | 32.16 | 8.22 | 16.733 |
| 40 | 46 | 6 | 140 | 120 | 6584 | 19600 | 5700 | 0.0020 | 0.267 | 29.67 | 7.93 | 22.509 |
| 50 | 52 | 12 | 153 | 150 | 7845 | 23409 | 7740 | 0.0021 | 0.284 | 27.17 | 7.73 | 21.602 |
| 60 | 55 | 15 | 166 | 180 | 9210 | 27556 | 10030 | 0.0028 | 0.292 | 24.95 | 7.29 | 18.772 |
| 70 | 59 | 19 | 182 | 210 | 11130 | 33124 | 12870 | 0.0015 | 0.303 | 22.99 | 6.96 | 26.116 |
| 80 | 68 | 28 | 203 | 240 | 13881 | 41209 | 16410 | 0.0012 | 0.325 | 21.03 | 6.84 | 29.172 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | 76 | 36 | 229 | 270 | 17625 | 52441 | 20780 | 0.0012 | 0.344 | 18.88 | 6.49 | 29.172 |
| 100 | 85 | 45 | 258 | 300 | 22410 | 66564 | 26010 | 0.0009 | 0.363 | 16.73 | 6.08 | 32.514 |
| 110 | 97 | 57 | 292 | 330 | 28734 | 85264 | 32370 | 0.0008 | 0.388 | 15.06 | 5.85 | 35.365 |
| 120 | 110 | 70 | 333 | 360 | 37385 | 110889 | 40250 | 0.0007 | 0.414 | 13.89 | 5.74 | 38.147 |
| 130 | 126 | 86 | 381 | 390 | 49001 | 145161 | 49880 | 0.0006 | 0.443 | 12.71 | 5.62 | 41.884 |
| 140 | 145 | 105 | 446 | 420 | 67526 | 198916 | 62930 | 0.0004 | 0.475 | 11.59 | 5.50 | 49.911 |
| 150 | 175 | 135 | 559 | 450 | 108771 | 312481 | 84790 | 0.0002 | 0.522 | 10.48 | 5.46 | 70.035 |
| 160 | 239 | 199 | 680 | 480 | 158502 | 462400 | 109710 | 0.0002 | 0.610 | 9.39 | 5.72 | 69.287 |
| 170 | 266 | 226 | 804 | 510 | 217278 | 646416 | 137280 | 0.0003 | 0.643 | 8.33 | 5.36 | 54.863 |
| 180 | 299 | 259 | 906 | 538 | 276438 | 820836 | 163148 | 0.0002 | 0.682 | 7.27 | 4.96 | 64.849 |
| 188 | 341 | 301 | | | | | | | 0.728 | 6.70 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine- low preheat ISO ign data- test 5** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | 0.249 | 33.88 | | |
| 20 | 42 | 2 | 125 | 60 | 5213 | 15625 | 2530 | 0.0064 | 0.256 | 32.87 | 8.40 | 12.472 |
| 30 | 43 | 3 | 132 | 90 | 5822 | 17424 | 4010 | 0.0036 | 0.259 | 32.16 | 8.31 | 16.733 |
| 40 | 47 | 7 | 143 | 120 | 6867 | 20449 | 5820 | 0.0020 | 0.270 | 29.67 | 8.02 | 22.509 |
| 50 | 53 | 13 | 163 | 150 | 8987 | 26569 | 8310 | 0.0012 | 0.287 | 27.17 | 7.80 | 28.577 |
| 60 | 63 | 23 | 190 | 180 | 12254 | 36100 | 11610 | 0.0010 | 0.313 | 24.95 | 7.81 | 32.416 |
| 70 | 74 | 34 | 219 | 210 | 16169 | 47961 | 15520 | 0.0010 | 0.339 | 22.99 | 7.80 | 30.950 |
| 80 | 82 | 42 | 247 | 240 | 20481 | 61009 | 19930 | 0.0012 | 0.357 | 21.03 | 7.51 | 29.172 |
| 90 | 91 | 51 | 279 | 270 | 26241 | 77841 | 25350 | 0.0008 | 0.376 | 18.88 | 7.10 | 35.000 |
| 100 | 106 | 66 | 323 | 300 | 35393 | 104329 | 32650 | 0.0006 | 0.406 | 16.73 | 6.79 | 41.975 |
| 110 | 126 | 86 | 382 | 330 | 49612 | 145924 | 42460 | 0.0005 | 0.443 | 15.06 | 6.67 | 46.969 |
| 120 | 150 | 110 | 450 | 360 | 68652 | 202500 | 54480 | 0.0004 | 0.483 | 13.89 | 6.70 | 48.990 |
| 130 | 174 | 134 | 532 | 390 | 96040 | 283024 | 69740 | 0.0003 | 0.520 | 12.71 | 6.61 | 54.118 |
| 140 | 208 | 168 | 635 | 420 | 137549 | 403225 | 89690 | 0.0003 | 0.569 | 11.59 | 6.59 | 63.052 |
| 150 | 253 | 213 | 745 | 450 | 187929 | 555025 | 112510 | 0.0003 | 0.627 | 10.48 | 6.57 | 61.992 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 284 | 244 | 864 | 480 | 251594 | 746496 | 138980 | 0.0003 | 0.664 | 9.39 | 6.24 | 61.094 |
| 170 | 327 | 287 | | | | | | | 0.713 | 8.33 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine- low preheat ISO ign data- test 6** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | 0.249 | 33.88 | | |
| 20 | 43 | 3 | 129 | 60 | 5565 | 16641 | 2640 | 0.0033 | 0.259 | 32.87 | 8.50 | 17.321 |
| 30 | 46 | 6 | 141 | 90 | 6669 | 19881 | 4320 | 0.0021 | 0.267 | 32.16 | 8.60 | 21.602 |
| 40 | 52 | 12 | 157 | 120 | 8301 | 24649 | 6410 | 0.0015 | 0.284 | 29.67 | 8.43 | 25.520 |
| 50 | 59 | 19 | 178 | 150 | 10674 | 31684 | 9050 | 0.0013 | 0.303 | 27.17 | 8.23 | 27.406 |
| 60 | 67 | 27 | 209 | 180 | 14859 | 43681 | 12780 | 0.0008 | 0.323 | 24.95 | 8.05 | 35.277 |
| 70 | 83 | 43 | 255 | 210 | 22403 | 65025 | 18230 | 0.0005 | 0.359 | 22.99 | 8.26 | 43.770 |
| 80 | 105 | 65 | 315 | 240 | 34043 | 99225 | 25640 | 0.0005 | 0.404 | 21.03 | 8.50 | 46.904 |
| 90 | 127 | 87 | 377 | 270 | 48179 | 142129 | 34330 | 0.0005 | 0.444 | 18.88 | 8.39 | 44.796 |
| 100 | 145 | 105 | 441 | 300 | 65715 | 194481 | 44520 | 0.0005 | 0.475 | 16.73 | 7.94 | 45.981 |
| 110 | 169 | 129 | 508 | 330 | 87222 | 258064 | 56370 | 0.0004 | 0.513 | 15.06 | 7.72 | 49.501 |
| 120 | 194 | 154 | 585 | 360 | 115481 | 342225 | 70730 | 0.0004 | 0.549 | 13.89 | 7.62 | 51.506 |
| 130 | 222 | 182 | 674 | 390 | 153484 | 454276 | 88260 | 0.0003 | 0.587 | 12.71 | 7.47 | 56.716 |
| 140 | 258 | 218 | 802 | 420 | 219532 | 643204 | 113280 | 0.0002 | 0.633 | 11.59 | 7.34 | 71.629 |
| 150 | 322 | 282 | 958 | 450 | 313132 | 917764 | 144900 | 0.0002 | 0.707 | 10.48 | 7.41 | 77.517 |
| 160 | 378 | 338 | 1203 | 480 | 499577 | 1447209 | 194290 | 0.0001 | 0.767 | 9.39 | 7.20 | 97.408 |
| 170 | 503 | 463 | | | | | | | 0.884 | 8.33 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine – full preheat – test 1** | Ignition Time | 643 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine – full preheat – test 2** | Ignition Time | 644 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 110 | 652 | 9 | | | | | | | 1.000 | 15.06 | | |
| 120 | 657 | 14 | 1969 | 360 | 1292353 | 3876961 | 236360 | 0.0024 | 1.000 | 13.89 | 13.89 | 20.207 |
| 130 | 660 | 17 | 1984 | 390 | 1312138 | 3936256 | 258020 | 0.0019 | 1.000 | 12.71 | 12.71 | 22.949 |
| 140 | 667 | 24 | 2002 | 420 | 1336114 | 4008004 | 280430 | 0.0013 | 1.000 | 11.59 | 11.59 | 27.406 |
| 150 | 675 | 32 | 2025 | 450 | 1367003 | 4100625 | 303910 | 0.0013 | 1.000 | 10.48 | 10.48 | 28.284 |
| 160 | 683 | 40 | 2051 | 480 | 1402363 | 4206601 | 328340 | 0.0011 | 1.000 | 9.39 | 9.39 | 30.062 |
| 170 | 693 | 50 | 2083 | 510 | 1446587 | 4338889 | 354350 | 0.0008 | 1.000 | 8.33 | 8.33 | 34.801 |
| 180 | 707 | 64 | 2127 | 540 | 1508627 | 4524129 | 383200 | 0.0006 | 1.000 | 7.27 | 7.27 | 41.445 |
| 190 | 727 | 84 | 2184 | 570 | 1590878 | 4769856 | 415390 | 0.0005 | 1.000 | 6.55 | 6.55 | 46.406 |
| 200 | 750 | 107 | 2235 | 600 | 1665593 | 4995225 | 447310 | 0.0006 | 1.000 | 5.83 | 5.83 | 40.877 |
| 210 | 758 | 115 | 2375 | 630 | 1888753 | 5640625 | 499920 | 0.0001 | 1.000 | 5.17 | 5.17 | 85.458 |
| 220 | 867 | 224 | 2543 | 660 | 2168977 | 6466849 | 561060 | 0.0001 | 1.000 | 4.58 | 4.58 | 91.381 |
| 230 | 918 | 275 | 2738 | 690 | 2502622 | 7496644 | 630600 | 0.0002 | 1.000 | 3.99 | 3.99 | 65.952 |
| 240 | 953 | 310 | 2855 | 711 | 2719189 | 8151025 | 677004 | 0.0002 | 1.000 | 3.77 | 3.77 | 76.874 |
| 241 | 984 | 341 | | | | | | | | 3.74 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine – full preheat – test 3** | Ignition Time | 40 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 648 | 4 | | | | | | | 1.000 | 16.73 | | |
| 110 | 650 | 6 | 1956 | 330 | 1275368 | 3825936 | 215260 | 0.0018 | 1.000 | 15.06 | 15.06 | 23.664 |
| 120 | 658 | 14 | 1973 | 360 | 1297689 | 3892729 | 236910 | 0.0013 | 1.000 | 13.89 | 13.89 | 27.406 |
| 130 | 665 | 21 | 1997 | 390 | 1329465 | 3988009 | 259770 | 0.0012 | 1.000 | 12.71 | 12.71 | 28.358 |
| 140 | 674 | 30 | 2028 | 420 | 1371222 | 4112784 | 284160 | 0.0008 | 1.000 | 11.59 | 11.59 | 35.000 |
| 150 | 689 | 45 | 2070 | 450 | 1428846 | 4284900 | 310830 | 0.0006 | 1.000 | 10.48 | 10.48 | 40.676 |
| 160 | 707 | 63 | 2120 | 480 | 1498746 | 4494400 | 339550 | 0.0006 | 1.000 | 9.39 | 9.39 | 41.839 |
| 170 | 724 | 80 | 2174 | 510 | 1576074 | 4726276 | 369940 | 0.0006 | 1.000 | 8.33 | 8.33 | 42.448 |
| 180 | 743 | 99 | 2229 | 540 | 1656869 | 4968441 | 401600 | 0.0005 | 1.000 | 7.27 | 7.27 | 43.589 |
| 190 | 762 | 118 | 2300 | 570 | 1764718 | 5290000 | 437520 | 0.0004 | 1.000 | 6.55 | 6.55 | 51.603 |
| 200 | 795 | 151 | 2376 | 600 | 1883430 | 5645376 | 475770 | 0.0003 | 1.000 | 5.83 | 5.83 | 53.607 |
| 210 | 819 | 175 | 2468 | 630 | 2032102 | 6091024 | 518870 | 0.0003 | 1.000 | 5.17 | 5.17 | 54.628 |
| 220 | 854 | 210 | 2556 | 660 | 2179766 | 6533136 | 562960 | 0.0003 | 1.000 | 4.58 | 4.58 | 56.651 |
| 230 | 883 | 239 | 2661 | 685 | 2362781 | 7080921 | 608110 | 0.0002 | 1.000 | 3.99 | 3.99 | 69.310 |
| 235 | 924 | 280 | | | | | | | | 3.88 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_e$* | *$\dot{q}''_e.F(t)$* | *$I/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Radiata Pine – full preheat – test 4** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 110 | 649 | 6 | | | | | | | | 15.06 | | |
| 120 | 654 | 11 | 1960 | 360 | 1280566 | 3841600 | 235280 | 0.0024 | 1.000 | 13.89 | 13.89 | 20.207 |
| 130 | 657 | 14 | 1974 | 390 | 1298934 | 3896676 | 256710 | 0.0021 | 1.000 | 12.71 | 12.71 | 21.602 |
| 140 | 663 | 20 | 1991 | 420 | 1321459 | 3964081 | 278880 | 0.0014 | 1.000 | 11.59 | 11.59 | 26.547 |
| 150 | 671 | 28 | 2015 | 450 | 1353571 | 4060225 | 302430 | 0.0011 | 1.000 | 10.48 | 10.48 | 30.062 |
| 160 | 681 | 38 | 2048 | 480 | 1398418 | 4194304 | 327930 | 0.0008 | 1.000 | 9.39 | 9.39 | 35.590 |
| 170 | 696 | 53 | 2088 | 510 | 1453698 | 4359744 | 355260 | 0.0007 | 1.000 | 8.33 | 8.33 | 38.730 |
| 180 | 711 | 68 | 2133 | 540 | 1517013 | 4549689 | 384240 | 0.0007 | 1.000 | 7.27 | 7.27 | 38.730 |
| 190 | 726 | 83 | 2186 | 570 | 1593598 | 4778596 | 415720 | 0.0005 | 1.000 | 6.55 | 6.55 | 43.910 |
| 200 | 749 | 106 | 2280 | 600 | 1736102 | 5198400 | 456790 | 0.0002 | 1.000 | 5.83 | 5.83 | 64.651 |
| 210 | 805 | 162 | 2393 | 630 | 1912947 | 5726449 | 503430 | 0.0002 | 1.000 | 5.17 | 5.17 | 67.747 |
| 220 | 839 | 196 | 2652 | 660 | 2368010 | 7033104 | 585470 | 0.0001 | 1.000 | 4.58 | 4.58 | 107.918 |
| 230 | 1008 | 365 | 2889 | 684 | 2805749 | 8346321 | 660248 | 0.0001 | 1.000 | 3.99 | 3.99 | 123.264 |
| 234 | 1042 | 399 | | | | | | | | 3.90 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | | | | | | | | | | | | |
| 100 | 649 | 5 | | | | | | | | 16.73 | | |
| 110 | 652 | 8 | 1959 | 330 | 1279269 | 3837681 | 215580 | 0.0021 | 1.000 | 15.06 | 15.06 | 21.602 |
| 120 | 658 | 14 | 1970 | 360 | 1293668 | 3880900 | 236480 | 0.0023 | 1.000 | 13.89 | 13.89 | 20.817 |
| 130 | 660 | 16 | 1988 | 390 | 1317464 | 3952144 | 258560 | 0.0015 | 1.000 | 12.71 | 12.71 | 26.247 |
| 140 | 670 | 26 | 2010 | 420 | 1346900 | 4040100 | 281600 | 0.0010 | 1.000 | 11.59 | 11.59 | 31.623 |
| 150 | 680 | 36 | 2042 | 450 | 1390164 | 4169764 | 306520 | 0.0009 | 1.000 | 10.48 | 10.48 | 33.212 |
| 160 | 692 | 48 | 2088 | 480 | 1453920 | 4359744 | 334440 | 0.0005 | 1.000 | 9.39 | 9.39 | 43.205 |
| 170 | 716 | 72 | 2145 | 510 | 1534689 | 4601025 | 365100 | 0.0004 | 1.000 | 8.33 | 8.33 | 47.469 |
| 180 | 737 | 93 | 2220 | 540 | 1644114 | 4928400 | 400110 | 0.0004 | 1.000 | 7.27 | 7.27 | 50.759 |
| 190 | 767 | 123 | 2305 | 570 | 1773059 | 5313025 | 438590 | 0.0003 | 1.000 | 6.55 | 6.55 | 56.605 |
| 200 | 801 | 157 | 2399 | 600 | 1920451 | 5755201 | 480440 | 0.0003 | 1.000 | 5.83 | 5.83 | 56.605 |
| 210 | 831 | 187 | 2482 | 630 | 2054662 | 6160324 | 521710 | 0.0004 | 1.000 | 5.17 | 5.17 | 49.911 |
| 220 | 850 | 206 | 2554 | 660 | 2175190 | 6522916 | 562300 | 0.0005 | 1.000 | 4.58 | 4.58 | 45.895 |
| 230 | 873 | 229 | 2620 | 690 | 2289238 | 6864400 | 603070 | 0.0004 | 1.000 | 3.99 | 3.99 | 48.480 |
| 240 | 897 | 253 | 2697 | 717 | 2426067 | 7273809 | 645039 | 0.0003 | 1.000 | 3.77 | 3.77 | 56.662 |
| 247 | 927 | 283 | | | | | | | 1.000 | 3.61 | | |

**Macrocarpa**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Macrocarpa Test 1** | Ignition Time | 291 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | 306 | 15 | | | | | | | 1.000 | 21.80 | 21.80 | |
| 175 | 309 | 18 | 926 | 525 | 285838 | 857476 | 162175 | 0.0099 | 1.000 | 20.60 | 20.60 | 10.066 |
| 200 | 311 | 20 | 935 | 600 | 291427 | 874225 | 187150 | 0.0080 | 1.000 | 18.95 | 18.95 | 11.155 |
| 225 | 315 | 24 | 945 | 675 | 297707 | 893025 | 212825 | 0.0063 | 1.000 | 17.29 | 17.29 | 12.649 |
| 250 | 319 | 28 | 957 | 750 | 305315 | 915849 | 239450 | 0.0063 | 1.000 | 15.33 | 15.33 | 12.649 |
| 275 | 323 | 32 | 969 | 825 | 313019 | 938961 | 266675 | 0.0063 | 1.000 | 13.37 | 13.37 | 12.649 |
| 300 | 327 | 36 | 988 | 900 | 325502 | 976144 | 296775 | 0.0031 | 1.000 | 11.56 | 11.56 | 17.938 |
| 325 | 338 | 47 | 1013 | 975 | 342277 | 1026169 | 329750 | 0.0024 | 1.000 | 9.75 | 9.75 | 20.502 |
| 350 | 348 | 57 | 1060 | 1050 | 375224 | 1123600 | 371900 | 0.0013 | 1.000 | 8.52 | 8.52 | 27.702 |
| 375 | 374 | 83 | 1105 | 1125 | 407669 | 1221025 | 415250 | 0.0013 | 1.000 | 7.28 | 7.28 | 27.478 |
| 400 | 383 | 92 | 1151 | 1200 | 441801 | 1324801 | 460900 | 0.0025 | 1.000 | 6.28 | 6.28 | 20.033 |
| 425 | 394 | 103 | 1198 | 1275 | 479166 | 1435204 | 510100 | 0.0012 | 1.000 | 5.27 | 5.27 | 28.371 |
| 450 | 421 | 130 | 1302 | 1350 | 569646 | 1695204 | 588225 | 0.0005 | 1.000 | 4.50 | 4.50 | 44.374 |
| 475 | 487 | 196 | 1471 | 1425 | 731379 | 2163841 | 702275 | 0.0004 | 1.000 | 3.72 | 3.72 | 53.336 |
| 500 | 563 | 272 | 1657 | 1500 | 922587 | 2745649 | 831500 | 0.0004 | 1.000 | 3.18 | 3.18 | 49.567 |
| 525 | 607 | 316 | 1928 | 1575 | 1259982 | 3717184 | 1017075 | 0.0002 | 1.000 | 2.63 | 2.63 | 65.509 |
| 550 | 758 | 467 | 2155 | 1635 | 1567113 | 4644025 | 1177975 | 0.0002 | 1.000 | 2.18 | 2.18 | 73.882 |
| 560 | 790 | 499 | | | | | | | 1.000 | 1.96 | 1.96 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Macrocarpa Test 2** | Ignition Time | 280 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | 25.20 | | |
| 75 | | | | | | | | | | 24.51 | | |
| 100 | | | | | | | | | | 23.75 | | |
| 125 | | | | | | | | | | 22.99 | | |
| 150 | | | | | | | | | | 21.80 | | |
| 175 | | | | | | | | | | 20.60 | | |
| 200 | 289 | 9 | | | | | | | 1.000 | 18.95 | | |
| 225 | 292 | 12 | 876 | 675 | 255810 | 767376 | 197250 | 0.0083 | 1.000 | 17.29 | 17.29 | 10.954 |
| 250 | 295 | 15 | 884 | 750 | 260498 | 781456 | 221125 | 0.0099 | 1.000 | 15.33 | 15.33 | 10.066 |
| 275 | 297 | 17 | 892 | 825 | 265234 | 795664 | 245425 | 0.0099 | 1.000 | 13.37 | 13.37 | 10.066 |
| 300 | 300 | 20 | 903 | 900 | 271845 | 815409 | 271125 | 0.0054 | 1.000 | 11.56 | 11.56 | 13.663 |
| 325 | 306 | 26 | 917 | 975 | 280357 | 840889 | 298300 | 0.0045 | 1.000 | 9.75 | 9.75 | 14.853 |
| 350 | 311 | 31 | 937 | 1050 | 292757 | 877969 | 328300 | 0.0035 | 1.000 | 8.52 | 8.52 | 16.959 |
| 375 | 320 | 40 | 963 | 1125 | 309345 | 927369 | 361650 | 0.0024 | 1.000 | 7.28 | 7.28 | 20.563 |
| 400 | 332 | 52 | 1002 | 1200 | 335124 | 1004004 | 401550 | 0.0016 | 1.000 | 6.28 | 6.28 | 24.658 |
| 425 | 350 | 70 | 1039 | 1275 | 360173 | 1079521 | 442200 | 0.0019 | 1.000 | 5.27 | 5.27 | 23.071 |
| 450 | 357 | 77 | 1086 | 1350 | 393590 | 1179396 | 489425 | 0.0016 | 1.000 | 4.50 | 4.50 | 25.134 |
| 475 | 379 | 99 | 1147 | 1425 | 440011 | 1315609 | 546175 | 0.0009 | 1.000 | 3.72 | 3.72 | 33.051 |
| 500 | 411 | 131 | 1242 | 1500 | 516866 | 1542564 | 622825 | 0.0007 | 1.000 | 3.18 | 3.18 | 38.307 |
| 525 | 452 | 172 | 1410 | 1575 | 672434 | 1988100 | 743650 | 0.0003 | 1.000 | 2.63 | 2.63 | 53.506 |
| 550 | 547 | 267 | | | | | | | 1.000 | 2.18 | 2.18 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT – Macrocarpa Test 3** | Ignition Time | 289 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | 25.20 | | |
| 75 | | | | | | | | | | 24.51 | | |
| 100 | | | | | | | | | | 23.75 | | |
| 125 | | | | | | | | | | 22.99 | | |
| 150 | | | | | | | | | | 21.80 | | |
| 175 | | | | | | | | | | 20.60 | | |
| 200 | | | | | | | | | | 18.95 | | |
| 225 | | | | | | | | | | 17.29 | | |
| 250 | 300 | 11 | | | | | | | 1.000 | 15.33 | | |
| 275 | 303 | 14 | 909 | 825 | 275445 | 826281 | 250125 | 0.0083 | 1.000 | 13.37 | 13.37 | 10.954 |
| 300 | 306 | 17 | 919 | 900 | 281545 | 844561 | 275875 | 0.0071 | 1.000 | 11.56 | 11.56 | 11.872 |
| 325 | 310 | 21 | 929 | 975 | 287705 | 863041 | 302100 | 0.0071 | 1.000 | 9.75 | 9.75 | 11.872 |
| 350 | 313 | 24 | 946 | 1050 | 298398 | 894916 | 331425 | 0.0035 | 1.000 | 8.52 | 8.52 | 16.886 |
| 375 | 323 | 34 | 969 | 1125 | 313187 | 938961 | 363875 | 0.0025 | 1.000 | 7.28 | 7.28 | 20.000 |
| 400 | 333 | 44 | 1002 | 1200 | 334934 | 1004004 | 401375 | 0.0022 | 1.000 | 6.28 | 6.28 | 21.508 |
| 425 | 346 | 57 | 1047 | 1275 | 366029 | 1096209 | 445850 | 0.0014 | 1.000 | 5.27 | 5.27 | 26.747 |
| 450 | 368 | 79 | 1107 | 1350 | 409589 | 1225449 | 499325 | 0.0011 | 1.000 | 4.50 | 4.50 | 30.680 |
| 475 | 393 | 104 | 1214 | 1425 | 495082 | 1473796 | 578775 | 0.0006 | 1.000 | 3.72 | 3.72 | 42.380 |
| 500 | 453 | 164 | 1330 | 1500 | 593914 | 1768900 | 667275 | 0.0005 | 1.000 | 3.18 | 3.18 | 43.378 |
| 525 | 484 | 195 | 1451 | 1562 | 703661 | 2105401 | 756618 | 0.0006 | 1.000 | 2.63 | 2.63 | 40.566 |
| 537 | 514 | 225 | | | | | | | 1.000 | 2.42 | 2.42 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa Low preheat – ISO ign- Test 1** | Ignition Time | 63 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 50 | 0 | | | | | | | | 33.88 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 51 | 1 | 153 | 60 | 7805 | 23409 | 3080 | 0.0100 | 0.342 | 32.87 | 11.25 | 10.000 |
| 30 | 52 | 2 | 156 | 90 | 8114 | 24336 | 4700 | 0.0100 | 0.346 | 32.16 | 11.11 | 10.000 |
| 40 | 53 | 3 | 159 | 120 | 8429 | 25281 | 6380 | 0.0100 | 0.349 | 29.67 | 10.35 | 10.000 |
| 50 | 54 | 4 | 162 | 150 | 8750 | 26244 | 8120 | 0.0100 | 0.352 | 27.17 | 9.57 | 10.000 |
| 60 | 55 | 5 | 165 | 180 | 9077 | 27225 | 9920 | 0.0100 | 0.355 | 24.95 | 8.87 | 10.000 |
| 70 | 56 | 6 | 168 | 210 | 9410 | 28224 | 11780 | 0.0100 | 0.359 | 22.99 | 8.24 | 10.000 |
| 80 | 57 | 7 | 175 | 240 | 10229 | 30625 | 14060 | 0.0029 | 0.362 | 21.03 | 7.61 | 18.559 |
| 90 | 62 | 12 | 184 | 270 | 11318 | 33856 | 16640 | 0.0024 | 0.377 | 18.88 | 7.12 | 20.207 |
| 100 | 65 | 15 | 196 | 300 | 12830 | 38416 | 19670 | 0.0028 | 0.386 | 16.73 | 6.46 | 18.772 |
| 110 | 69 | 19 | 211 | 330 | 14915 | 44521 | 23330 | 0.0016 | 0.398 | 15.06 | 5.99 | 24.944 |
| 120 | 77 | 27 | 238 | 360 | 19154 | 56644 | 28790 | 0.0008 | 0.420 | 13.89 | 5.84 | 34.431 |
| 130 | 92 | 42 | 276 | 390 | 25842 | 76176 | 36180 | 0.0007 | 0.460 | 12.71 | 5.84 | 38.730 |
| 140 | 107 | 57 | 343 | 420 | 40649 | 117649 | 48540 | 0.0004 | 0.496 | 11.59 | 5.75 | 52.489 |
| 150 | 144 | 94 | 413 | 450 | 58429 | 170569 | 62500 | 0.0003 | 0.575 | 10.48 | 6.02 | 53.473 |
| 160 | 162 | 112 | 479 | 480 | 76909 | 229441 | 76930 | 0.0007 | 0.610 | 9.39 | 5.73 | 38.447 |
| 170 | 173 | 123 | 520 | 510 | 90398 | 270400 | 88630 | 0.0009 | 0.630 | 8.33 | 5.25 | 33.922 |
| 180 | 185 | 135 | 630 | 540 | 138138 | 396900 | 114390 | 0.0002 | 0.652 | 7.27 | 4.74 | 76.792 |
| 190 | 272 | 222 | 754 | 570 | 196418 | 568516 | 144380 | 0.0002 | 0.790 | 6.55 | 5.18 | 78.562 |
| 200 | 297 | 247 | 889 | 600 | 264593 | 790321 | 178280 | 0.0004 | 0.826 | 5.83 | 4.81 | 49.004 |
| 210 | 320 | 270 | 959 | 630 | 307573 | 919681 | 201840 | 0.0004 | 0.857 | 5.17 | 4.43 | 47.438 |
| 220 | 342 | 292 | 1023 | 651 | 349685 | 1046529 | 222221 | 0.0003 | 0.886 | 4.58 | 4.06 | 60.505 |
| 221 | 361 | 311 | | | | | | | 0.910 | 4.52 | 4.12 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa Low preheat – ISO ign- Test 2** | Ignition Time | 50 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 63 | 0 | | | | | | | | 33.88 | | |
| 20 | 64 | 1 | 193 | 60 | 12421 | 37249 | 3890 | 0.0064 | 0.383 | 32.87 | 12.60 | 12.472 |
| 30 | 66 | 3 | 198 | 90 | 13076 | 39204 | 5980 | 0.0050 | 0.389 | 32.16 | 12.52 | 14.142 |
| 40 | 68 | 5 | 203 | 120 | 13741 | 41209 | 8150 | 0.0064 | 0.395 | 29.67 | 11.72 | 12.472 |
| 50 | 69 | 6 | 210 | 150 | 14714 | 44100 | 10550 | 0.0036 | 0.398 | 27.17 | 10.82 | 16.733 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 73 | 10 | 221 | 180 | 16331 | 48841 | 13360 | 0.0020 | 0.409 | 24.95 | 10.21 | 22.509 |
| 70 | 79 | 16 | 240 | 210 | 19314 | 57600 | 16950 | 0.0013 | 0.426 | 22.99 | 9.79 | 27.568 |
| 80 | 88 | 25 | 267 | 240 | 23985 | 71289 | 21570 | 0.0009 | 0.449 | 21.03 | 9.45 | 32.514 |
| 90 | 100 | 37 | 302 | 270 | 30740 | 91204 | 27440 | 0.0008 | 0.479 | 18.88 | 9.05 | 36.091 |
| 100 | 114 | 51 | 349 | 300 | 41221 | 121801 | 35250 | 0.0006 | 0.512 | 16.73 | 8.56 | 42.111 |
| 110 | 135 | 72 | 406 | 330 | 55870 | 164836 | 45090 | 0.0005 | 0.557 | 15.06 | 8.38 | 46.372 |
| 120 | 157 | 94 | 479 | 360 | 77843 | 229441 | 58000 | 0.0004 | 0.600 | 13.89 | 8.34 | 51.191 |
| 130 | 187 | 124 | 568 | 390 | 109794 | 322624 | 74510 | 0.0003 | 0.655 | 12.71 | 8.33 | 57.984 |
| 140 | 224 | 161 | 673 | 420 | 153789 | 452929 | 94970 | 0.0003 | 0.717 | 11.59 | 8.31 | 61.239 |
| 150 | 262 | 199 | 808 | 450 | 222504 | 652864 | 122180 | 0.0002 | 0.776 | 10.48 | 8.12 | 70.586 |
| 160 | 322 | 259 | 948 | 480 | 304824 | 898704 | 152700 | 0.0002 | 0.860 | 9.39 | 8.07 | 71.784 |
| 170 | 364 | 301 | 1105 | 510 | 411741 | 1221025 | 188820 | 0.0002 | 0.914 | 8.33 | 7.62 | 69.850 |
| 180 | 419 | 356 | 1307 | 535 | 582633 | 1708249 | 234240 | 0.0001 | 0.981 | 7.27 | 7.13 | 106.818 |
| 185 | 524 | 461 | | | | | | | 1.000 | 6.91 | 6.91 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa Low preheat – ISO ign- Test 3** | Ignition Time | 40 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | | 33.88 | | |
| 20 | 41 | 1 | 124 | 60 | 5130 | 15376 | 2510 | 0.0064 | 0.307 | 32.87 | 10.09 | 12.472 |
| 30 | 43 | 3 | 128 | 90 | 5466 | 16384 | 3870 | 0.0064 | 0.314 | 32.16 | 10.10 | 12.472 |
| 40 | 44 | 4 | 132 | 120 | 5810 | 17424 | 5300 | 0.0100 | 0.318 | 29.67 | 9.43 | 10.000 |
| 50 | 45 | 5 | 135 | 150 | 6077 | 18225 | 6770 | 0.0100 | 0.321 | 27.17 | 8.73 | 10.000 |
| 60 | 46 | 6 | 141 | 180 | 6641 | 19881 | 8510 | 0.0036 | 0.325 | 24.95 | 8.11 | 16.733 |
| 70 | 50 | 10 | 152 | 210 | 7752 | 23104 | 10740 | 0.0020 | 0.339 | 22.99 | 7.79 | 22.509 |
| 80 | 56 | 16 | 168 | 240 | 9480 | 28224 | 13560 | 0.0017 | 0.359 | 21.03 | 7.54 | 24.495 |
| 90 | 62 | 22 | 188 | 270 | 11880 | 35344 | 17060 | 0.0014 | 0.377 | 18.88 | 7.12 | 26.547 |
| 100 | 70 | 30 | 217 | 300 | 15969 | 47089 | 21930 | 0.0008 | 0.401 | 16.73 | 6.71 | 34.431 |
| 110 | 85 | 45 | 254 | 330 | 21926 | 64516 | 28230 | 0.0007 | 0.442 | 15.06 | 6.65 | 38.086 |
| 120 | 99 | 59 | 305 | 360 | 31667 | 93025 | 36960 | 0.0005 | 0.477 | 13.89 | 6.62 | 42.774 |
| 130 | 121 | 81 | 358 | 390 | 43486 | 128164 | 46930 | 0.0005 | 0.527 | 12.71 | 6.70 | 44.280 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 | 138 | 98 | 423 | 420 | 60581 | 178929 | 59650 | 0.0005 | 0.563 | 11.59 | 6.53 | 46.705 |
| 150 | 164 | 124 | 501 | 450 | 85541 | 251001 | 75760 | 0.0003 | 0.614 | 10.48 | 6.43 | 55.427 |
| 160 | 199 | 159 | 570 | 480 | 109346 | 324900 | 91630 | 0.0004 | 0.676 | 9.39 | 6.35 | 49.321 |
| 170 | 207 | 167 | 664 | 510 | 149014 | 440896 | 113470 | 0.0003 | 0.689 | 8.33 | 5.74 | 58.926 |
| 180 | 258 | 218 | 751 | 540 | 191209 | 564001 | 135970 | 0.0002 | 0.770 | 7.27 | 5.60 | 63.731 |
| 190 | 286 | 246 | 871 | 570 | 255289 | 758641 | 166180 | 0.0003 | 0.810 | 6.55 | 5.31 | 59.083 |
| 200 | 327 | 287 | 965 | 594 | 312629 | 931225 | 191548 | 0.0002 | 0.866 | 5.83 | 5.05 | 68.160 |
| 204 | 352 | 312 | | | | | | | 0.899 | 5.57 | 5.00 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa Low preheat – ISO ign- Test 4** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | | 33.88 | | |
| 20 | 41 | 1 | 123 | 60 | 5045 | 15129 | 2480 | 0.0100 | 0.307 | 32.87 | 10.09 | 10.000 |
| 30 | 42 | 2 | 128 | 90 | 5470 | 16384 | 3880 | 0.0046 | 0.311 | 32.16 | 9.99 | 14.720 |
| 40 | 45 | 5 | 134 | 120 | 5998 | 17956 | 5410 | 0.0039 | 0.321 | 29.67 | 9.54 | 15.916 |
| 50 | 47 | 7 | 145 | 150 | 7043 | 21025 | 7330 | 0.0023 | 0.328 | 27.17 | 8.93 | 20.817 |
| 60 | 53 | 13 | 155 | 180 | 8043 | 24025 | 9380 | 0.0023 | 0.349 | 24.95 | 8.70 | 20.817 |
| 70 | 55 | 15 | 166 | 210 | 9198 | 27556 | 11670 | 0.0039 | 0.355 | 22.99 | 8.17 | 15.916 |
| 80 | 58 | 18 | 185 | 240 | 11573 | 34225 | 14970 | 0.0010 | 0.365 | 21.03 | 7.68 | 31.123 |
| 90 | 72 | 32 | 211 | 270 | 15109 | 44521 | 19220 | 0.0009 | 0.407 | 18.88 | 7.68 | 34.178 |
| 100 | 81 | 41 | 243 | 300 | 19845 | 59049 | 24480 | 0.0011 | 0.431 | 16.73 | 7.21 | 30.000 |
| 110 | 90 | 50 | 301 | 330 | 31561 | 90601 | 33600 | 0.0004 | 0.455 | 15.06 | 6.85 | 52.696 |
| 120 | 130 | 90 | 370 | 360 | 47500 | 136900 | 45000 | 0.0003 | 0.546 | 13.89 | 7.59 | 55.777 |
| 130 | 150 | 110 | 456 | 390 | 70376 | 207936 | 59740 | 0.0004 | 0.587 | 12.71 | 7.46 | 48.094 |
| 140 | 176 | 136 | 537 | 420 | 97997 | 288369 | 75790 | 0.0003 | 0.636 | 11.59 | 7.37 | 55.427 |
| 150 | 211 | 171 | 627 | 450 | 133097 | 393129 | 94690 | 0.0003 | 0.696 | 10.48 | 7.29 | 56.651 |
| 160 | 240 | 200 | 724 | 480 | 176650 | 524176 | 116460 | 0.0003 | 0.742 | 9.39 | 6.97 | 55.716 |
| 170 | 273 | 233 | 853 | 510 | 247729 | 727609 | 146010 | 0.0002 | 0.792 | 8.33 | 6.60 | 72.060 |
| 180 | 340 | 300 | 992 | 540 | 333770 | 984064 | 179620 | 0.0002 | 0.883 | 7.27 | 6.43 | 73.643 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 190 | 379 | 339 | | | | | | | 0.933 | 6.55 | | |
| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
| **RIFT – Macrocarpa Low preheat – ISO ign- Test 5** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | | 33.88 | | |
| 20 | 43 | 3 | 129 | 60 | 5565 | 16641 | 2640 | 0.0033 | 0.314 | 32.87 | 10.33 | 17.321 |
| 30 | 46 | 6 | 136 | 90 | 6174 | 18496 | 4120 | 0.0046 | 0.325 | 32.16 | 10.45 | 14.720 |
| 40 | 47 | 7 | 142 | 120 | 6726 | 20164 | 5710 | 0.0064 | 0.328 | 29.67 | 9.74 | 12.472 |
| 50 | 49 | 9 | 148 | 150 | 7314 | 21904 | 7450 | 0.0039 | 0.335 | 27.17 | 9.11 | 15.916 |
| 60 | 52 | 12 | 156 | 180 | 8130 | 24336 | 9420 | 0.0033 | 0.346 | 24.95 | 8.62 | 17.321 |
| 70 | 55 | 15 | 169 | 210 | 9573 | 28561 | 11930 | 0.0019 | 0.355 | 22.99 | 8.17 | 22.949 |
| 80 | 62 | 22 | 187 | 240 | 11769 | 34969 | 15110 | 0.0013 | 0.377 | 21.03 | 7.94 | 27.406 |
| 90 | 70 | 30 | 213 | 270 | 15305 | 45369 | 19360 | 0.0010 | 0.401 | 18.88 | 7.57 | 30.950 |
| 100 | 81 | 41 | 246 | 300 | 20486 | 60516 | 24850 | 0.0008 | 0.431 | 16.73 | 7.21 | 35.440 |
| 110 | 95 | 55 | 284 | 330 | 27250 | 80656 | 31510 | 0.0007 | 0.467 | 15.06 | 7.03 | 36.751 |
| 120 | 108 | 68 | 320 | 360 | 34378 | 102400 | 38620 | 0.0009 | 0.498 | 13.89 | 6.91 | 33.348 |
| 130 | 117 | 77 | 355 | 390 | 42253 | 126025 | 46370 | 0.0009 | 0.518 | 12.71 | 6.59 | 33.348 |
| 140 | 130 | 90 | 392 | 420 | 51614 | 153664 | 55160 | 0.0007 | 0.546 | 11.59 | 6.33 | 37.448 |
| 150 | 145 | 105 | 438 | 450 | 64494 | 191844 | 66030 | 0.0006 | 0.577 | 10.48 | 6.04 | 40.676 |
| 160 | 163 | 123 | 502 | 480 | 85230 | 252004 | 80810 | 0.0004 | 0.612 | 9.39 | 5.74 | 50.075 |
| 170 | 194 | 154 | 587 | 510 | 117105 | 344569 | 100460 | 0.0003 | 0.667 | 8.33 | 5.56 | 57.933 |
| 180 | 230 | 190 | 681 | 533 | 156585 | 463761 | 121411 | 0.0002 | 0.727 | 7.27 | 5.29 | 68.972 |
| 183 | 257 | 217 | | | | | | | 0.768 | 7.06 | | |
| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
| **RIFT – Macrocarpa Low preheat – ISO ign- Test 6** | Ignition Time | 40 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 40 | 0 | | | | | | | | 33.88 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 42 | 2 | 126 | 60 | 5300 | 15876 | 2560 | 0.0050 | 0.311 | 32.87 | 10.21 | 14.142 |
| 30 | 44 | 4 | 131 | 90 | 5725 | 17161 | 3960 | 0.0064 | 0.318 | 32.16 | 10.22 | 12.472 |
| 40 | 45 | 5 | 137 | 120 | 6265 | 18769 | 5520 | 0.0046 | 0.321 | 29.67 | 9.54 | 14.720 |
| 50 | 48 | 8 | 143 | 150 | 6829 | 20449 | 7200 | 0.0039 | 0.332 | 27.17 | 9.02 | 15.916 |
| 60 | 50 | 10 | 154 | 180 | 7940 | 23716 | 9320 | 0.0023 | 0.339 | 24.95 | 8.45 | 20.817 |
| 70 | 56 | 16 | 170 | 210 | 9732 | 28900 | 12040 | 0.0014 | 0.359 | 22.99 | 8.24 | 26.547 |
| 80 | 64 | 24 | 198 | 240 | 13316 | 39204 | 16060 | 0.0009 | 0.383 | 21.03 | 8.06 | 33.575 |
| 90 | 78 | 38 | 240 | 270 | 19784 | 57600 | 21940 | 0.0006 | 0.423 | 18.88 | 7.99 | 41.445 |
| 100 | 98 | 58 | 295 | 300 | 29849 | 87025 | 29910 | 0.0005 | 0.474 | 16.73 | 7.93 | 45.281 |
| 110 | 119 | 79 | 364 | 330 | 45374 | 132496 | 40530 | 0.0004 | 0.523 | 15.06 | 7.87 | 49.666 |
| 120 | 147 | 107 | 437 | 360 | 65011 | 190969 | 52960 | 0.0004 | 0.581 | 13.89 | 8.07 | 51.040 |
| 130 | 171 | 131 | 522 | 390 | 92466 | 272484 | 68430 | 0.0003 | 0.627 | 12.71 | 7.96 | 53.607 |
| 140 | 204 | 164 | 611 | 420 | 126553 | 373321 | 86190 | 0.0003 | 0.684 | 11.59 | 7.93 | 57.011 |
| 150 | 236 | 196 | 716 | 450 | 173488 | 512656 | 108120 | 0.0003 | 0.736 | 10.48 | 7.71 | 60.123 |
| 160 | 276 | 236 | 852 | 480 | 247472 | 725904 | 137360 | 0.0002 | 0.796 | 9.39 | 7.47 | 72.748 |
| 170 | 340 | 300 | 994 | 510 | 334660 | 988036 | 170000 | 0.0002 | 0.883 | 8.33 | 7.36 | 72.183 |
| 180 | 378 | 338 | 1138 | 540 | 434884 | 1295044 | 205640 | 0.0002 | 0.932 | 7.27 | 6.78 | 63.272 |
| 190 | 420 | 380 | 1261 | 565 | 533653 | 1590121 | 238125 | 0.0002 | 0.982 | 6.55 | 6.43 | 75.328 |
| 195 | 463 | 423 | | | | | | | | 6.19 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_e$ | $\dot{q}''_e . F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa – full preheat – test 1** | Ignition Time | 436 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | 441 | 5 | | | | | | | 1.000 | 22.99 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 446 | 10 | 1334 | 240 | 593206 | 1779556 | 106780 | 0.0029 | 1.000 | 21.03 | 21.03 | 18.559 |
| 90 | 447 | 11 | 1342 | 270 | 600326 | 1800964 | 120810 | 0.0064 | 1.000 | 18.88 | 18.88 | 12.472 |
| 100 | 449 | 13 | 1350 | 300 | 607526 | 1822500 | 135070 | 0.0027 | 1.000 | 16.73 | 16.73 | 19.272 |
| 110 | 454 | 18 | 1363 | 330 | 619317 | 1857769 | 150040 | 0.0018 | 1.000 | 15.06 | 15.06 | 23.484 |
| 120 | 460 | 24 | 1384 | 360 | 638616 | 1915456 | 166240 | 0.0012 | 1.000 | 13.89 | 13.89 | 28.577 |
| 130 | 470 | 34 | 1411 | 390 | 663861 | 1990921 | 183640 | 0.0010 | 1.000 | 12.71 | 12.71 | 32.416 |
| 140 | 481 | 45 | 1446 | 420 | 697286 | 2090916 | 202690 | 0.0008 | 1.000 | 11.59 | 11.59 | 35.440 |
| 150 | 495 | 59 | 1504 | 450 | 755170 | 2262016 | 226070 | 0.0004 | 1.000 | 10.48 | 10.48 | 49.780 |
| 160 | 528 | 92 | 1570 | 480 | 823018 | 2464900 | 251720 | 0.0004 | 1.000 | 9.39 | 9.39 | 51.603 |
| 170 | 547 | 111 | 1645 | 510 | 902893 | 2706025 | 280070 | 0.0005 | 1.000 | 8.33 | 8.33 | 45.895 |
| 180 | 570 | 134 | 1712 | 540 | 978134 | 2930944 | 308640 | 0.0004 | 1.000 | 7.27 | 7.27 | 49.004 |
| 190 | 595 | 159 | 1792 | 570 | 1072054 | 3211264 | 341050 | 0.0003 | 1.000 | 6.55 | 6.55 | 53.519 |
| 200 | 627 | 191 | 1882 | 594 | 1182754 | 3541924 | 373090 | 0.0002 | 1.000 | 5.83 | 5.83 | 68.216 |
| 204 | 660 | 224 | | | | | | | | 5.57 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa – full preheat – test 2** | Ignition Time | 438 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | 445 | 7 | | | | | | | 1.000 | 22.99 | | |
| 80 | 448 | 10 | 1344 | 240 | 602130 | 1806336 | 107580 | 0.0033 | 1.000 | 21.03 | 21.03 | 17.321 |
| 90 | 451 | 13 | 1352 | 270 | 609314 | 1827904 | 121730 | 0.0039 | 1.000 | 18.88 | 18.88 | 15.916 |
| 100 | 453 | 15 | 1360 | 300 | 616546 | 1849600 | 136050 | 0.0039 | 1.000 | 16.73 | 16.73 | 15.916 |
| 110 | 456 | 18 | 1369 | 330 | 624745 | 1874161 | 150660 | 0.0028 | 1.000 | 15.06 | 15.06 | 18.772 |
| 120 | 460 | 22 | 1381 | 360 | 635761 | 1907161 | 165810 | 0.0022 | 1.000 | 13.89 | 13.89 | 21.257 |
| 130 | 465 | 27 | 1402 | 390 | 655354 | 1965604 | 182430 | 0.0011 | 1.000 | 12.71 | 12.71 | 29.967 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 | 477 | 39 | 1435 | 420 | 686803 | 2059225 | 201180 | 0.0007 | 1.000 | 11.59 | 11.59 | 37.544 |
| 150 | 493 | 55 | 1473 | 450 | 723587 | 2169729 | 221210 | 0.0008 | 1.000 | 10.48 | 10.48 | 36.374 |
| 160 | 503 | 65 | 1510 | 480 | 760254 | 2280100 | 241810 | 0.0010 | 1.000 | 9.39 | 9.39 | 32.416 |
| 170 | 514 | 76 | 1551 | 510 | 802361 | 2405601 | 263980 | 0.0006 | 1.000 | 8.33 | 8.33 | 39.919 |
| 180 | 534 | 96 | 1613 | 540 | 868577 | 2601769 | 290850 | 0.0004 | 1.000 | 7.27 | 7.27 | 50.888 |
| 190 | 565 | 127 | 1725 | 570 | 996257 | 2975625 | 328670 | 0.0002 | 1.000 | 6.55 | 6.55 | 69.015 |
| 200 | 626 | 188 | 1840 | 600 | 1132302 | 3385600 | 368840 | 0.0002 | 1.000 | 5.83 | 5.83 | 66.981 |
| 210 | 649 | 211 | 1951 | 630 | 1270053 | 3806401 | 410210 | 0.0004 | 1.000 | 5.17 | 5.17 | 50.053 |
| 220 | 676 | 238 | | | | | | | 1.000 | 4.58 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa – full preheat – test 3** | Ignition Time | 438 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | 446 | 8 | | | | | | | 1.000 | 22.99 | | |
| 80 | 447 | 9 | 1341 | 240 | 599429 | 1798281 | 107300 | 0.0100 | 1.000 | 21.03 | 21.03 | 10.000 |
| 90 | 448 | 10 | 1344 | 270 | 602114 | 1806336 | 120980 | 0.0100 | 1.000 | 18.88 | 18.88 | 10.000 |
| 100 | 449 | 11 | 1347 | 300 | 604805 | 1814409 | 134720 | 0.0100 | 1.000 | 16.73 | 16.73 | 10.000 |
| 110 | 450 | 12 | 1351 | 330 | 608405 | 1825201 | 148640 | 0.0064 | 1.000 | 15.06 | 15.06 | 12.472 |
| 120 | 452 | 14 | 1356 | 360 | 612920 | 1838736 | 162760 | 0.0050 | 1.000 | 13.89 | 13.89 | 14.142 |
| 130 | 454 | 16 | 1362 | 390 | 618356 | 1855044 | 177100 | 0.0050 | 1.000 | 12.71 | 12.71 | 14.142 |
| 140 | 456 | 18 | 1369 | 420 | 624733 | 1874161 | 191710 | 0.0039 | 1.000 | 11.59 | 11.59 | 15.916 |
| 150 | 459 | 21 | 1381 | 450 | 635773 | 1907161 | 207250 | 0.0019 | 1.000 | 10.48 | 10.48 | 22.949 |
| 160 | 466 | 28 | 1402 | 480 | 655366 | 1965604 | 224500 | 0.0011 | 1.000 | 9.39 | 9.39 | 30.246 |
| 170 | 477 | 39 | 1438 | 510 | 689710 | 2067844 | 244750 | 0.0007 | 1.000 | 8.33 | 8.33 | 38.447 |
| 180 | 495 | 57 | 1516 | 540 | 768490 | 2298256 | 273550 | 0.0003 | 1.000 | 7.27 | 7.27 | 59.909 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 190 | 544 | 106 | 1601 | 570 | 856805 | 2563201 | 304860 | 0.0003 | 1.000 | 6.55 | 6.55 | 59.909 |
| 200 | 562 | 124 | | | | | | | | 5.83 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Macrocarpa – full preheat – test 4** | Ignition Time | 443 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | 448 | 5 | | | | | | | | 22.99 | | |
| 80 | 450 | 7 | 1351 | 240 | 608413 | 1825201 | 108130 | 0.0039 | 1.000 | 21.03 | 21.03 | 15.916 |
| 90 | 453 | 10 | 1359 | 270 | 615645 | 1846881 | 122370 | 0.0033 | 1.000 | 18.88 | 18.88 | 17.321 |
| 100 | 456 | 13 | 1368 | 300 | 623826 | 1871424 | 136860 | 0.0033 | 1.000 | 16.73 | 16.73 | 17.321 |
| 110 | 459 | 16 | 1375 | 330 | 630217 | 1890625 | 151290 | 0.0046 | 1.000 | 15.06 | 15.06 | 14.720 |
| 120 | 460 | 17 | 1381 | 360 | 635725 | 1907161 | 165750 | 0.0064 | 1.000 | 13.89 | 13.89 | 12.472 |
| 130 | 462 | 19 | 1387 | 390 | 641269 | 1923769 | 180360 | 0.0039 | 1.000 | 12.71 | 12.71 | 15.916 |
| 140 | 465 | 22 | 1397 | 420 | 650569 | 1951609 | 195660 | 0.0024 | 1.000 | 11.59 | 11.59 | 20.207 |
| 150 | 470 | 27 | 1409 | 450 | 661801 | 1985281 | 211440 | 0.0022 | 1.000 | 10.48 | 10.48 | 21.257 |
| 160 | 474 | 31 | 1423 | 480 | 675017 | 2024929 | 227770 | 0.0022 | 1.000 | 9.39 | 9.39 | 21.257 |
| 170 | 479 | 36 | 1446 | 510 | 697166 | 2090916 | 246010 | 0.0010 | 1.000 | 8.33 | 8.33 | 31.954 |
| 180 | 493 | 50 | 1488 | 540 | 738746 | 2214144 | 268210 | 0.0005 | 1.000 | 7.27 | 7.27 | 43.434 |
| 190 | 516 | 73 | 1543 | 570 | 794461 | 2380849 | 293580 | 0.0005 | 1.000 | 6.55 | 6.55 | 45.389 |
| 200 | 534 | 91 | 1602 | 600 | 856116 | 2566404 | 320760 | 0.0006 | 1.000 | 5.83 | 5.83 | 42.426 |
| 210 | 552 | 109 | 1656 | 630 | 914760 | 2742336 | 348120 | 0.0006 | 1.000 | 5.17 | 5.17 | 42.426 |
| 220 | 570 | 127 | 1719 | 657 | 986013 | 2954961 | 376839 | 0.0004 | 1.000 | 4.58 | 4.58 | 52.099 |
| 227 | 597 | 154 | | | | | | | | 4.17 | | |

**Rimu**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Rimu test 1** | Ignition Time | 715 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 50 | | | | | | | | | | #N/A | | |
| 75 | | | | | | | | | | 26.45 | | |
| 100 | 720 | 5 | | | | | | | 1.000 | 26.10 | 26.10 | |
| 125 | 721 | 6 | 2165 | 375 | 1562417 | 4687225 | 270725 | 0.0115 | 1.000 | 25.30 | 25.30 | 9.309 |
| 150 | 724 | 9 | 2171 | 450 | 1571093 | 4713241 | 325775 | 0.0099 | 1.000 | 24.50 | 24.50 | 10.066 |
| 175 | 726 | 11 | 2178 | 525 | 1581236 | 4743684 | 381250 | 0.0125 | 1.000 | 23.20 | 23.20 | 8.944 |
| 200 | 728 | 13 | 2191 | 600 | 1600229 | 4800481 | 438475 | 0.0040 | 1.000 | 21.90 | 21.90 | 15.802 |
| 225 | 737 | 22 | 2206 | 675 | 1622234 | 4866436 | 496675 | 0.0037 | 1.000 | 20.70 | 20.70 | 16.517 |
| 250 | 741 | 26 | 2223 | 750 | 1647275 | 4941729 | 555950 | 0.0063 | 1.000 | 19.50 | 19.50 | 12.649 |
| 275 | 745 | 30 | 2237 | 825 | 1668107 | 5004169 | 615425 | 0.0049 | 1.000 | 18.00 | 18.00 | 14.236 |
| 300 | 751 | 36 | 2251 | 900 | 1689051 | 5067001 | 675550 | 0.0049 | 1.000 | 16.50 | 16.50 | 14.236 |
| 325 | 755 | 40 | 2269 | 975 | 1716195 | 5148361 | 737725 | 0.0040 | 1.000 | 14.85 | 14.85 | 15.776 |
| 350 | 763 | 48 | 2300 | 1050 | 1763718 | 5290000 | 805675 | 0.0018 | 1.000 | 13.20 | 13.20 | 23.872 |
| 375 | 782 | 67 | 2367 | 1117 | 1869377 | 5602689 | 882524 | 0.0007 | 1.000 | 11.50 | 11.50 | 38.703 |
| 392 | 822 | 107 | | | | | | | 1.000 | 10.34 | 10.34 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Rimu test 2** | Ignition Time | 717 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 729 | 12 | | | | | | | 1.000 | 21.90 | 21.90 | |
| 225 | 731 | 14 | 2193 | 675 | 1603091 | 4809249 | 493525 | 0.0125 | 1.000 | 20.70 | 20.70 | 8.944 |
| 250 | 733 | 16 | 2201 | 750 | 1614819 | 4844401 | 550400 | 0.0080 | 1.000 | 19.50 | 19.50 | 11.155 |
| 275 | 737 | 20 | 2213 | 825 | 1632507 | 4897369 | 608825 | 0.0049 | 1.000 | 18.00 | 18.00 | 14.236 |
| 300 | 743 | 26 | 2227 | 900 | 1653227 | 4959529 | 668350 | 0.0049 | 1.000 | 16.50 | 16.50 | 14.236 |
| 325 | 747 | 30 | 2244 | 975 | 1678574 | 5035536 | 729575 | 0.0044 | 1.000 | 14.85 | 14.85 | 15.015 |
| 350 | 754 | 37 | 2269 | 1050 | 1716349 | 5148361 | 794675 | 0.0023 | 1.000 | 13.20 | 13.20 | 20.870 |
| 375 | 768 | 51 | 2308 | 1125 | 1776136 | 5326864 | 866300 | 0.0016 | 1.000 | 11.50 | 11.50 | 25.364 |
| 400 | 786 | 69 | 2370 | 1200 | 1873476 | 5616900 | 949200 | 0.0010 | 1.000 | 9.80 | 9.80 | 31.305 |
| 425 | 816 | 99 | 2458 | 1275 | 2016388 | 6041764 | 1046400 | 0.0007 | 1.000 | 8.35 | 8.35 | 37.544 |
| 450 | 856 | 139 | 2576 | 1350 | 2215808 | 6635776 | 1161400 | 0.0006 | 1.000 | 6.90 | 6.90 | 42.010 |
| 475 | 904 | 187 | 2752 | 1425 | 2534016 | 7573504 | 1310600 | 0.0004 | 1.000 | 5.95 | 5.95 | 52.900 |
| 500 | 992 | 275 | | | | | | | 1.000 | 5.00 | 5.00 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT Rimu test 3** | Ignition Time | 736 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 225 | | | | | | | | | | | | |
| 250 | | | | | | | | | | | | |
| 275 | | | | | | | | | | | | |
| 300 | 750 | 14 | | | | | | | 1.000 | 16.50 | 16.50 | |
| 325 | 761 | 25 | 2282 | 975 | 1736062 | 5207524 | 742175 | 0.0024 | 1.000 | 14.85 | 14.85 | 20.502 |
| 350 | 771 | 35 | 2325 | 1050 | 1802411 | 5405625 | 814550 | 0.0015 | 1.000 | 13.20 | 13.20 | 25.884 |
| 375 | 793 | 57 | 2387 | 1125 | 1900619 | 5697769 | 896425 | 0.0010 | 1.000 | 11.50 | 11.50 | 32.376 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 | 823 | 87 | 2492 | 1200 | 2073554 | 6210064 | 998875 | 0.0006 | 1.000 | 9.80 | 9.80 | 41.261 |
| 425 | 876 | 140 | 2639 | 1265 | 2328305 | 6964321 | 1115100 | 0.0003 | 1.000 | 8.35 | 8.35 | 54.376 |
| 440 | 940 | 204 | | | | | | | 1.000 | 7.48 | 7.48 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Rimu – Low preheat – ISO ign data – Test 1** | Ignition Time | 80 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | | 33.88 | | |
| 20 | 61 | 1 | 184 | 60 | 11290 | 33856 | 3710 | 0.0064 | 0.392 | 32.87 | 12.89 | 12.472 |
| 30 | 63 | 3 | 189 | 90 | 11915 | 35721 | 5710 | 0.0050 | 0.399 | 32.16 | 12.82 | 14.142 |
| 40 | 65 | 5 | 197 | 120 | 12955 | 38809 | 7940 | 0.0032 | 0.405 | 29.67 | 12.01 | 17.638 |
| 50 | 69 | 9 | 208 | 150 | 14462 | 43264 | 10490 | 0.0022 | 0.417 | 27.17 | 11.33 | 21.257 |
| 60 | 74 | 14 | 227 | 180 | 17293 | 51529 | 13770 | 0.0013 | 0.432 | 24.95 | 10.78 | 27.889 |
| 70 | 84 | 24 | 249 | 210 | 20813 | 62001 | 17600 | 0.0012 | 0.460 | 22.99 | 10.58 | 29.306 |
| 80 | 91 | 31 | 276 | 240 | 25538 | 76176 | 22250 | 0.0012 | 0.479 | 21.03 | 10.07 | 29.306 |
| 90 | 101 | 41 | 302 | 270 | 30582 | 91204 | 27370 | 0.0011 | 0.505 | 18.88 | 9.53 | 30.836 |
| 100 | 110 | 50 | 330 | 300 | 36462 | 108900 | 33180 | 0.0011 | 0.527 | 16.73 | 8.81 | 30.000 |
| 110 | 119 | 59 | 358 | 330 | 42902 | 128164 | 39570 | 0.0011 | 0.548 | 15.06 | 8.25 | 30.836 |
| 120 | 129 | 69 | 393 | 360 | 51827 | 154449 | 47420 | 0.0008 | 0.570 | 13.89 | 7.92 | 36.374 |
| 130 | 145 | 85 | 434 | 390 | 63266 | 188356 | 56730 | 0.0006 | 0.605 | 12.71 | 7.68 | 39.377 |
| 140 | 160 | 100 | 492 | 415 | 81594 | 242064 | 68365 | 0.0003 | 0.635 | 11.59 | 7.36 | 54.502 |
| 145 | 187 | 127 | | | | | | | 0.687 | 11.59 | 7.96 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Rimu – Low preheat – ISO ign data – Test 2** | Ignition Time | 80 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 63 | 0 | | | | | | | | 33.88 | | |
| 20 | 64 | 1 | 193 | 60 | 12421 | 37249 | 3890 | 0.0064 | 0.402 | 32.87 | 13.20 | 12.472 |
| 30 | 66 | 3 | 199 | 90 | 13213 | 39601 | 6020 | 0.0039 | 0.408 | 32.16 | 13.12 | 15.916 |
| 40 | 69 | 6 | 207 | 120 | 14301 | 42849 | 8340 | 0.0033 | 0.417 | 29.67 | 12.37 | 17.321 |
| 50 | 72 | 9 | 218 | 150 | 15874 | 47524 | 10980 | 0.0024 | 0.426 | 27.17 | 11.58 | 20.207 |
| 60 | 77 | 14 | 232 | 180 | 18002 | 53824 | 14030 | 0.0018 | 0.441 | 24.95 | 10.99 | 23.484 |
| 70 | 83 | 20 | 253 | 210 | 21467 | 64009 | 17870 | 0.0012 | 0.457 | 22.99 | 10.52 | 28.577 |
| 80 | 93 | 30 | 281 | 240 | 26563 | 78961 | 22700 | 0.0009 | 0.484 | 21.03 | 10.18 | 33.212 |
| 90 | 105 | 42 | 316 | 270 | 33598 | 99856 | 28690 | 0.0008 | 0.514 | 18.88 | 9.71 | 35.365 |
| 100 | 118 | 55 | 356 | 300 | 42638 | 126736 | 35880 | 0.0007 | 0.545 | 16.73 | 9.12 | 37.448 |
| 110 | 133 | 70 | 402 | 330 | 54414 | 161604 | 44550 | 0.0006 | 0.579 | 15.06 | 8.72 | 40.676 |
| 120 | 151 | 88 | 449 | 360 | 67715 | 201601 | 54200 | 0.0006 | 0.617 | 13.89 | 8.57 | 40.104 |
| 130 | 165 | 102 | 505 | 389 | 85747 | 255025 | 65841 | 0.0005 | 0.645 | 12.71 | 8.20 | 45.339 |
| 139 | 189 | 126 | | | | | | | 0.690 | 12.71 | 8.77 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Rimu – Low preheat – ISO ign data – Test 3** | Ignition Time | 69 | | | | | | m/s | | kW/m² | | (m/s)$^{-0.5}$ |
| 10 | 63 | 0 | | | | | | | | 33.88 | | |
| 20 | 64 | 1 | 192 | 60 | 12290 | 36864 | 3860 | 0.0100 | 0.402 | 32.87 | 13.20 | 10.000 |
| 30 | 65 | 2 | 199 | 90 | 13221 | 39601 | 6030 | 0.0029 | 0.405 | 32.16 | 13.02 | 18.559 |
| 40 | 70 | 7 | 212 | 120 | 15054 | 44944 | 8600 | 0.0017 | 0.420 | 29.67 | 12.46 | 24.608 |
| 50 | 77 | 14 | 230 | 150 | 17718 | 52900 | 11630 | 0.0015 | 0.441 | 27.17 | 11.97 | 25.520 |
| 60 | 83 | 20 | 246 | 180 | 20214 | 60516 | 14850 | 0.0021 | 0.457 | 24.95 | 11.41 | 21.602 |
| 70 | 86 | 23 | 259 | 210 | 22385 | 67081 | 18200 | 0.0028 | 0.466 | 22.99 | 10.71 | 18.772 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 90 | 27 | 277 | 240 | 25697 | 76729 | 22310 | 0.0012 | 0.476 | 21.03 | 10.02 | 28.363 |
| 90 | 101 | 38 | 312 | 270 | 32942 | 97344 | 28390 | 0.0006 | 0.505 | 18.88 | 9.53 | 39.919 |
| 100 | 121 | 58 | 360 | 300 | 43886 | 129600 | 36370 | 0.0005 | 0.552 | 16.73 | 9.24 | 43.059 |
| 110 | 138 | 75 | 411 | 330 | 56789 | 168921 | 45520 | 0.0006 | 0.590 | 15.06 | 8.88 | 39.431 |
| 120 | 152 | 89 | 465 | 355 | 72773 | 216225 | 55295 | 0.0004 | 0.619 | 13.89 | 8.59 | 50.845 |
| 125 | 175 | 112 | | | | | | | 0.664 | 13.89 | 9.22 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Rimu – Low preheat – ISO ign data – Test 4** | Ignition Time | 66 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | | 33.88 | | |
| 20 | 61 | 1 | 183 | 60 | 11165 | 33489 | 3680 | 0.0100 | 0.392 | 32.87 | 12.89 | 10.000 |
| 30 | 62 | 2 | 187 | 90 | 11661 | 34969 | 5640 | 0.0064 | 0.395 | 32.16 | 12.71 | 12.472 |
| 40 | 64 | 4 | 191 | 120 | 12165 | 36481 | 7670 | 0.0064 | 0.402 | 29.67 | 11.92 | 12.472 |
| 50 | 65 | 5 | 195 | 150 | 12677 | 38025 | 9770 | 0.0100 | 0.405 | 27.17 | 11.00 | 10.000 |
| 60 | 66 | 6 | 201 | 180 | 13481 | 40401 | 12110 | 0.0036 | 0.408 | 24.95 | 10.18 | 16.733 |
| 70 | 70 | 10 | 210 | 210 | 14732 | 44100 | 14780 | 0.0025 | 0.420 | 22.99 | 9.66 | 20.000 |
| 80 | 74 | 14 | 224 | 240 | 16776 | 50176 | 18020 | 0.0020 | 0.432 | 21.03 | 9.08 | 22.509 |
| 90 | 80 | 20 | 242 | 270 | 19620 | 58564 | 21920 | 0.0014 | 0.449 | 18.88 | 8.48 | 26.547 |
| 100 | 88 | 28 | 265 | 300 | 23553 | 70225 | 26670 | 0.0012 | 0.471 | 16.73 | 7.88 | 29.172 |
| 110 | 97 | 37 | 291 | 330 | 28389 | 84681 | 32190 | 0.0011 | 0.494 | 15.06 | 7.45 | 30.000 |
| 120 | 106 | 46 | 320 | 360 | 34334 | 102400 | 38600 | 0.0010 | 0.517 | 13.89 | 7.18 | 31.675 |
| 130 | 117 | 57 | 354 | 390 | 42086 | 125316 | 46270 | 0.0008 | 0.543 | 12.71 | 6.90 | 35.440 |
| 140 | 131 | 71 | 391 | 420 | 51299 | 152881 | 55000 | 0.0008 | 0.575 | 11.59 | 6.66 | 36.091 |
| 150 | 143 | 83 | 431 | 450 | 62259 | 185761 | 64910 | 0.0008 | 0.600 | 10.48 | 6.29 | 36.091 |
| 160 | 157 | 97 | 468 | 480 | 73322 | 219024 | 75130 | 0.0008 | 0.629 | 9.39 | 5.91 | 35.440 |
| 170 | 168 | 108 | 522 | 505 | 91682 | 272484 | 88155 | 0.0003 | 0.651 | 8.33 | 5.42 | 54.740 |
| 175 | 197 | 137 | | | | | | | 0.705 | 7.80 | 5.50 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT – Rimu – Low preheat – ISO ign data – Test 5** | Ignition Time | 67 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 50 | 0 | | | | | | | | 33.88 | | |
| 20 | 51 | 1 | 153 | 60 | 7805 | 23409 | 3080 | 0.0100 | 0.359 | 32.87 | 11.79 | 10.000 |
| 30 | 52 | 2 | 156 | 90 | 8114 | 24336 | 4700 | 0.0100 | 0.362 | 32.16 | 11.64 | 10.000 |
| 40 | 53 | 3 | 160 | 120 | 8538 | 25600 | 6430 | 0.0064 | 0.366 | 29.67 | 10.84 | 12.472 |
| 50 | 55 | 5 | 173 | 150 | 10059 | 29929 | 8770 | 0.0015 | 0.372 | 27.17 | 10.12 | 26.247 |
| 60 | 65 | 15 | 194 | 180 | 12726 | 37636 | 11830 | 0.0011 | 0.405 | 24.95 | 10.10 | 30.836 |
| 70 | 74 | 24 | 224 | 210 | 16926 | 50176 | 15880 | 0.0010 | 0.432 | 22.99 | 9.93 | 31.675 |
| 80 | 85 | 35 | 251 | 240 | 21165 | 63001 | 20260 | 0.0011 | 0.463 | 21.03 | 9.74 | 30.246 |
| 90 | 92 | 42 | 283 | 270 | 26925 | 80089 | 25680 | 0.0009 | 0.482 | 18.88 | 9.09 | 32.998 |
| 100 | 106 | 56 | 331 | 300 | 37389 | 109561 | 33510 | 0.0005 | 0.517 | 16.73 | 8.65 | 46.029 |
| 110 | 133 | 83 | 398 | 330 | 54206 | 158404 | 44310 | 0.0004 | 0.579 | 15.06 | 8.72 | 51.481 |
| 120 | 159 | 109 | 478 | 362 | 77566 | 228484 | 58262 | 0.0004 | 0.633 | 13.89 | 8.79 | 49.071 |
| 132 | 186 | 136 | | | | | | | 0.685 | 12.71 | | |

**There was insufficient flame spread for a full –preheat result for Rimu in the RIFT**

**NZ** Beech

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $I/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT** – Beech – **Test 1** | Ignition Time | 415 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 225 | 427 | 12 | | | | | | | 1.000 | 17.29 | 17.29 | |
| 250 | 429 | 14 | 1296 | 750 | 559970 | 1679616 | 324325 | 0.0033 | 1.000 | 15.55 | 15.55 | 17.365 |
| 275 | 440 | 25 | 1319 | 825 | 580141 | 1739761 | 363250 | 0.0024 | 1.000 | 13.37 | 13.37 | 20.502 |
| 300 | 450 | 35 | 1359 | 900 | 616061 | 1846881 | 408425 | 0.0017 | 1.000 | 11.19 | 11.19 | 24.467 |
| 325 | 469 | 54 | 1415 | 975 | 668477 | 2002225 | 461025 | 0.0011 | 1.000 | 9.75 | 9.75 | 30.484 |
| 350 | 496 | 81 | 1493 | 1050 | 744761 | 2229049 | 524025 | 0.0008 | 1.000 | 8.32 | 8.32 | 34.392 |
| 375 | 528 | 113 | 1615 | 1125 | 874081 | 2608225 | 608000 | 0.0005 | 1.000 | 7.28 | 7.28 | 44.356 |
| 400 | 591 | 176 | 1786 | 1200 | 1072954 | 3189796 | 717875 | 0.0004 | 1.000 | 6.25 | 6.25 | 52.803 |
| 425 | 667 | 252 | 1976 | 1275 | 1309694 | 3904576 | 842975 | 0.0004 | 1.000 | 5.27 | 5.27 | 50.723 |
| 450 | 718 | 303 | 2206 | 1350 | 1634454 | 4866436 | 996550 | 0.0003 | 1.000 | 4.29 | 4.29 | 56.543 |
| 475 | 821 | 406 | 2457 | 1414 | 2032289 | 6036849 | 1161977 | 0.0002 | 1.000 | 3.72 | 3.72 | 71.521 |
| 489 | 918 | 503 | | | | | | | 1.000 | 3.72 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIFT** – Beech – **Test 2** | Ignition Time | 397 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | 416 | 1 | 834 | 300 | 347780 | 695556 | 93850 | 0.00009 | 1.000 | 23.82 | 23.82 | |
| 125 | 418 | 21 | 1254 | 375 | 524180 | 1572516 | 156850 | 0.01250 | 1.000 | 22.99 | 22.99 | 8.944 |
| 150 | 420 | 23 | 1260 | 450 | 529208 | 1587600 | 189100 | 0.01250 | 1.000 | 22.16 | 22.16 | 8.944 |
| 175 | 422 | 25 | 1267 | 525 | 535109 | 1605289 | 221850 | 0.00987 | 1.000 | 20.60 | 20.60 | 10.066 |
| 200 | 425 | 28 | 1274 | 600 | 541038 | 1623076 | 254925 | 0.00987 | 1.000 | 19.04 | 19.04 | 10.066 |
| 225 | 427 | 30 | 1282 | 675 | 547854 | 1643524 | 288575 | 0.00987 | 1.000 | 17.29 | 17.29 | 10.066 |
| 250 | 430 | 33 | 1302 | 750 | 565254 | 1695204 | 325950 | 0.00242 | 1.000 | 15.55 | 15.55 | 20.331 |
| 275 | 445 | 48 | 1332 | 825 | 591774 | 1774224 | 366975 | 0.00184 | 1.000 | 13.37 | 13.37 | 23.286 |
| 300 | 457 | 60 | 1373 | 900 | 628715 | 1885129 | 412550 | 0.00192 | 1.000 | 11.19 | 11.19 | 22.826 |
| 325 | 471 | 74 | 1422 | 975 | 674726 | 2022084 | 463075 | 0.00133 | 1.000 | 9.75 | 9.75 | 27.470 |
| 350 | 494 | 97 | 1487 | 1050 | 738361 | 2211169 | 521725 | 0.00098 | 1.000 | 8.32 | 8.32 | 31.989 |
| 375 | 522 | 125 | 1579 | 1125 | 833489 | 2493241 | 593850 | 0.00072 | 1.000 | 7.28 | 7.28 | 37.367 |
| 400 | 563 | 166 | 1706 | 1200 | 975094 | 2910436 | 684875 | 0.00050 | 1.000 | 6.25 | 6.25 | 44.715 |
| 425 | 621 | 224 | 1870 | 1262 | 1173206 | 3496900 | 788907 | 0.00030 | 1.000 | 5.27 | 5.27 | 57.881 |
| 437 | 686 | 289 | | | | | | | 1.000 | 5.27 | | |

**LIFT test 3**

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ignition Time | 397 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 50 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 412 | 15 | | | | | | | 1.000 | 22.16 | | |
| 175 | 413 | 16 | 1242 | 525 | 514202 | 1542564 | 217475 | 0.0089 | 1.000 | 20.60 | 20.60 | 10.583 |
| 200 | 417 | 20 | 1250 | 600 | 520858 | 1562500 | 250175 | 0.0071 | 1.000 | 19.04 | 19.04 | 11.872 |
| 225 | 420 | 23 | 1270 | 675 | 537778 | 1612900 | 286150 | 0.0028 | 1.000 | 17.29 | 17.29 | 19.018 |
| 250 | 433 | 36 | 1294 | 750 | 558370 | 1674436 | 324025 | 0.0023 | 1.000 | 15.55 | 15.55 | 20.687 |
| 275 | 441 | 44 | 1333 | 825 | 592651 | 1776889 | 367225 | 0.0018 | 1.000 | 13.37 | 13.37 | 23.359 |
| 300 | 459 | 62 | 1382 | 900 | 637486 | 1909924 | 415625 | 0.0012 | 1.000 | 11.19 | 11.19 | 28.707 |
| 325 | 482 | 85 | 1448 | 975 | 700054 | 2096704 | 471800 | 0.0010 | 1.000 | 9.75 | 9.75 | 30.993 |
| 350 | 507 | 110 | 1524 | 1050 | 775598 | 2322576 | 534725 | 0.0009 | 1.000 | 8.32 | 8.32 | 32.575 |
| 375 | 535 | 138 | 1612 | 1125 | 868174 | 2598544 | 606075 | 0.0008 | 1.000 | 7.28 | 7.28 | 35.569 |
| 400 | 570 | 173 | 1725 | 1200 | 995525 | 2975625 | 692125 | 0.0006 | 1.000 | 6.25 | 6.25 | 41.445 |
| 425 | 620 | 223 | 1893 | 1275 | 1203509 | 3583449 | 807850 | 0.0004 | 1.000 | 5.27 | 5.27 | 52.102 |
| 450 | 703 | 306 | | | | | | | 1.000 | 4.29 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT** – Beech – **Low preheat - test 1** | Ignition Time | 55 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 55 | 0 | | | | | | | | 33.88 | | |
| 20 | 56 | 1 | 169 | 60 | 9525 | 28561 | 3410 | 0.0064 | 0.397 | 32.87 | 13.05 | 12.472 |
| 30 | 58 | 3 | 174 | 90 | 10100 | 30276 | 5260 | 0.0050 | 0.404 | 32.16 | 13.00 | 14.142 |
| 40 | 60 | 5 | 182 | 120 | 11060 | 33124 | 7340 | 0.0032 | 0.411 | 29.67 | 12.19 | 17.638 |
| 50 | 64 | 9 | 193 | 150 | 12457 | 37249 | 9740 | 0.0022 | 0.424 | 27.17 | 11.54 | 21.257 |
| 60 | 69 | 14 | 209 | 180 | 14633 | 43681 | 12660 | 0.0017 | 0.441 | 24.95 | 11.00 | 24.608 |
| 70 | 76 | 21 | 230 | 210 | 17762 | 52900 | 16260 | 0.0012 | 0.463 | 22.99 | 10.64 | 28.358 |
| 80 | 85 | 30 | 255 | 240 | 21837 | 65025 | 20580 | 0.0011 | 0.489 | 21.03 | 10.29 | 30.000 |
| 90 | 94 | 39 | 283 | 270 | 26877 | 80089 | 25660 | 0.0011 | 0.514 | 18.88 | 9.71 | 30.836 |
| 100 | 104 | 49 | 311 | 300 | 32421 | 96721 | 31290 | 0.0011 | 0.541 | 16.73 | 9.05 | 30.836 |
| 110 | 113 | 58 | 344 | 330 | 39714 | 118336 | 38070 | 0.0009 | 0.564 | 15.06 | 8.50 | 34.178 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 127 | 72 | 387 | 360 | 50507 | 149769 | 46780 | 0.0006 | 0.598 | 13.89 | 8.30 | 41.445 |
| 130 | 147 | 92 | 445 | 390 | 66979 | 198025 | 58290 | 0.0005 | 0.643 | 12.71 | 8.18 | 46.969 |
| 140 | 171 | 116 | 508 | 420 | 86950 | 258064 | 71550 | 0.0005 | 0.694 | 11.59 | 8.04 | 46.472 |
| 150 | 190 | 135 | | | | | | | | 10.48 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT –** Beech – **Low preheat - test 2** | Ignition Time | 55 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 55 | 0 | | | | | | | 0.394 | 33.88 | | |
| 20 | 57 | 2 | 172 | 60 | 9874 | 29584 | 3490 | 0.0039 | 0.401 | 32.87 | 13.17 | 15.916 |
| 30 | 60 | 5 | 180 | 90 | 10818 | 32400 | 5460 | 0.0033 | 0.411 | 32.16 | 13.22 | 17.321 |
| 40 | 63 | 8 | 192 | 120 | 12330 | 36864 | 7770 | 0.0021 | 0.421 | 29.67 | 12.49 | 21.602 |
| 50 | 69 | 14 | 211 | 150 | 14971 | 44521 | 10710 | 0.0012 | 0.441 | 27.17 | 11.98 | 28.577 |
| 60 | 79 | 24 | 238 | 180 | 19102 | 56644 | 14490 | 0.0010 | 0.472 | 24.95 | 11.77 | 32.416 |
| 70 | 90 | 35 | 274 | 210 | 25366 | 75076 | 19440 | 0.0008 | 0.503 | 22.99 | 11.57 | 36.197 |
| 80 | 105 | 50 | 315 | 240 | 33525 | 99225 | 25500 | 0.0007 | 0.544 | 21.03 | 11.44 | 38.730 |
| 90 | 120 | 65 | 360 | 270 | 43650 | 129600 | 32700 | 0.0007 | 0.581 | 18.88 | 10.97 | 38.730 |
| 100 | 135 | 80 | 410 | 300 | 56650 | 168100 | 41350 | 0.0006 | 0.617 | 16.73 | 10.31 | 41.975 |
| 110 | 155 | 100 | 468 | 330 | 73934 | 219024 | 51910 | 0.0005 | 0.661 | 15.06 | 9.95 | 46.406 |
| 120 | 178 | 123 | 536 | 360 | 96918 | 287296 | 64800 | 0.0004 | 0.708 | 13.89 | 9.83 | 49.004 |
| 130 | 203 | 148 | 601 | 385 | 121293 | 361201 | 77450 | 0.0004 | 0.756 | 12.71 | 9.61 | 52.679 |
| 135 | 220 | 165 | | | | | | | 0.787 | 12.71 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT –** Beech – **Low preheat - test 3** | Ignition Time | 60 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | 0.411 | 33.88 | | |
| 20 | 61 | 1 | 184 | 60 | 11290 | 33856 | 3710 | 0.0064 | 0.414 | 32.87 | 13.62 | 12.472 |
| 30 | 63 | 3 | 188 | 90 | 11786 | 35344 | 5670 | 0.0064 | 0.421 | 32.16 | 13.54 | 12.472 |
| 40 | 64 | 4 | 194 | 120 | 12554 | 37636 | 7800 | 0.0046 | 0.424 | 29.67 | 12.59 | 14.720 |
| 50 | 67 | 7 | 202 | 150 | 13626 | 40804 | 10170 | 0.0028 | 0.434 | 27.17 | 11.80 | 18.772 |
| 60 | 71 | 11 | 214 | 180 | 15306 | 45796 | 12930 | 0.0022 | 0.447 | 24.95 | 11.15 | 21.257 |
| 70 | 76 | 16 | 233 | 210 | 18213 | 54289 | 16460 | 0.0013 | 0.463 | 22.99 | 10.64 | 27.889 |
| 80 | 86 | 26 | 257 | 240 | 22197 | 66049 | 20750 | 0.0011 | 0.492 | 21.03 | 10.35 | 30.836 |
| 90 | 95 | 35 | 282 | 270 | 26622 | 79524 | 25530 | 0.0013 | 0.517 | 18.88 | 9.76 | 27.568 |
| 100 | 101 | 41 | 306 | 300 | 31326 | 93636 | 30750 | 0.0013 | 0.533 | 16.73 | 8.92 | 27.568 |
| 110 | 110 | 50 | 334 | 330 | 37430 | 111556 | 36960 | 0.0009 | 0.557 | 15.06 | 8.38 | 33.348 |
| 120 | 123 | 63 | 378 | 360 | 48254 | 142884 | 45710 | 0.0006 | 0.588 | 13.89 | 8.17 | 42.292 |
| 130 | 145 | 85 | 426 | 390 | 61118 | 181476 | 55730 | 0.0006 | 0.639 | 12.71 | 8.12 | 42.292 |
| 140 | 158 | 98 | 480 | 420 | 77318 | 230400 | 67520 | 0.0006 | 0.667 | 11.59 | 7.73 | 40.234 |
| 150 | 177 | 117 | 529 | 450 | 93929 | 279841 | 79710 | 0.0006 | 0.706 | 10.48 | 7.40 | 42.448 |
| 160 | 194 | 134 | 588 | 480 | 116054 | 345744 | 94480 | 0.0005 | 0.739 | 9.39 | 6.94 | 44.889 |
| 170 | 217 | 157 | 642 | 510 | 138086 | 412164 | 109510 | 0.0005 | 0.782 | 8.33 | 6.51 | 43.434 |
| 180 | 231 | 171 | | | | | | | 0.806 | 7.27 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT –** Beech – **Low preheat - test 4** | Ignition Time | 60 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | 0.411 | 33.88 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 61 | 1 | 183 | 60 | 11165 | 33489 | 3680 | 0.0100 | 0.414 | 32.87 | 13.62 | 10.000 |
| 30 | 62 | 2 | 188 | 90 | 11790 | 35344 | 5680 | 0.0046 | 0.418 | 32.16 | 13.44 | 14.720 |
| 40 | 65 | 5 | 194 | 120 | 12558 | 37636 | 7810 | 0.0039 | 0.428 | 29.67 | 12.69 | 15.916 |
| 50 | 67 | 7 | 205 | 150 | 14043 | 42025 | 10330 | 0.0023 | 0.434 | 27.17 | 11.80 | 20.817 |
| 60 | 73 | 13 | 218 | 180 | 15902 | 47524 | 13190 | 0.0018 | 0.453 | 24.95 | 11.31 | 23.484 |
| 70 | 78 | 18 | 237 | 210 | 18809 | 56169 | 16720 | 0.0015 | 0.469 | 22.99 | 10.77 | 25.720 |
| 80 | 86 | 26 | 258 | 240 | 22316 | 66564 | 20800 | 0.0013 | 0.492 | 21.03 | 10.35 | 28.284 |
| 90 | 94 | 34 | 283 | 270 | 26841 | 80089 | 25640 | 0.0012 | 0.514 | 18.88 | 9.71 | 29.172 |
| 100 | 103 | 43 | 312 | 300 | 32670 | 97344 | 31410 | 0.0009 | 0.539 | 16.73 | 9.01 | 32.514 |
| 110 | 115 | 55 | 349 | 330 | 40995 | 121801 | 38670 | 0.0007 | 0.569 | 15.06 | 8.57 | 37.544 |
| 120 | 131 | 71 | 389 | 360 | 50835 | 151321 | 46960 | 0.0007 | 0.607 | 13.89 | 8.43 | 37.544 |
| 130 | 143 | 83 | 431 | 390 | 62259 | 185761 | 56290 | 0.0008 | 0.635 | 12.71 | 8.06 | 36.091 |
| 140 | 157 | 97 | 476 | 420 | 76074 | 226576 | 66970 | 0.0006 | 0.665 | 11.59 | 7.71 | 40.775 |
| 150 | 176 | 116 | 541 | 450 | 98889 | 292681 | 81660 | 0.0004 | 0.704 | 10.48 | 7.37 | 51.041 |
| 160 | 208 | 148 | 611 | 480 | 125769 | 373321 | 98270 | 0.0004 | 0.765 | 9.39 | 7.19 | 51.041 |
| 170 | 227 | 167 | 697 | 503 | 163437 | 485809 | 117196 | 0.0002 | 0.799 | 8.33 | 6.66 | 67.198 |
| 173 | 262 | 202 | | | | | | | 0.859 | 8.33 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT –** Beech – **Low preheat - test 5** | Ignition Time | 60s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | 0.411 | 33.88 | | |
| 20 | 61 | 1 | 183 | 60 | 11165 | 33489 | 3680 | 0.0100 | 0.414 | 32.87 | 13.62 | 10.000 |
| 30 | 62 | 2 | 186 | 90 | 11534 | 34596 | 5600 | 0.0100 | 0.418 | 32.16 | 13.44 | 10.000 |
| 40 | 63 | 3 | 191 | 120 | 12169 | 36481 | 7680 | 0.0046 | 0.421 | 29.67 | 12.49 | 14.720 |
| 50 | 66 | 6 | 200 | 150 | 13366 | 40000 | 10080 | 0.0024 | 0.431 | 27.17 | 11.71 | 20.207 |
| 60 | 71 | 11 | 210 | 180 | 14726 | 44100 | 12670 | 0.0027 | 0.447 | 24.95 | 11.15 | 19.272 |
| 70 | 73 | 13 | 222 | 210 | 16454 | 49284 | 15610 | 0.0027 | 0.453 | 22.99 | 10.42 | 19.272 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 78 | 18 | 237 | 240 | 18809 | 56169 | 19090 | 0.0015 | 0.469 | 21.03 | 9.86 | 25.720 |
| 90 | 86 | 26 | 261 | 270 | 22889 | 68121 | 23680 | 0.0010 | 0.492 | 18.88 | 9.29 | 30.950 |
| 100 | 97 | 37 | 296 | 300 | 29574 | 87616 | 29870 | 0.0007 | 0.523 | 16.73 | 8.74 | 36.952 |
| 110 | 113 | 53 | 334 | 330 | 37554 | 111556 | 37010 | 0.0007 | 0.564 | 15.06 | 8.50 | 36.952 |
| 120 | 124 | 64 | 380 | 360 | 48594 | 144400 | 45900 | 0.0007 | 0.591 | 13.89 | 8.20 | 39.186 |
| 130 | 143 | 83 | 422 | 390 | 59850 | 178084 | 55170 | 0.0006 | 0.635 | 12.71 | 8.06 | 39.703 |
| 140 | 155 | 95 | 467 | 420 | 73035 | 218089 | 65640 | 0.0008 | 0.661 | 11.59 | 7.66 | 36.091 |
| 150 | 169 | 109 | 510 | 450 | 87182 | 260100 | 76810 | 0.0006 | 0.690 | 10.48 | 7.23 | 39.431 |
| 160 | 186 | 126 | 560 | 480 | 105182 | 313600 | 89960 | 0.0006 | 0.724 | 9.39 | 6.79 | 42.448 |
| 170 | 205 | 145 | | | | | | | 0.760 | 8.33 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT –** Beech – **Low preheat - test 6** | Ignition Time | 60s | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 60 | 0 | | | | | | | 0.411 | 33.88 | | |
| 20 | 61 | 1 | 183 | 60 | 11165 | 33489 | 3680 | 0.0100 | 0.414 | 32.87 | 13.62 | 10.000 |
| 30 | 62 | 2 | 188 | 90 | 11790 | 35344 | 5680 | 0.0046 | 0.418 | 32.16 | 13.44 | 14.720 |
| 40 | 65 | 5 | 195 | 120 | 12693 | 38025 | 7860 | 0.0033 | 0.428 | 29.67 | 12.69 | 17.321 |
| 50 | 68 | 8 | 204 | 150 | 13890 | 41616 | 10260 | 0.0033 | 0.438 | 27.17 | 11.89 | 17.321 |
| 60 | 71 | 11 | 215 | 180 | 15441 | 46225 | 12980 | 0.0024 | 0.447 | 24.95 | 11.15 | 20.207 |
| 70 | 76 | 16 | 229 | 210 | 17541 | 52441 | 16140 | 0.0018 | 0.463 | 22.99 | 10.64 | 23.484 |
| 80 | 82 | 22 | 246 | 240 | 20244 | 60516 | 19800 | 0.0017 | 0.480 | 21.03 | 10.11 | 24.495 |
| 90 | 88 | 28 | 265 | 270 | 23493 | 70225 | 23980 | 0.0015 | 0.498 | 18.88 | 9.40 | 25.520 |
| 100 | 95 | 35 | 286 | 300 | 27378 | 81796 | 28750 | 0.0013 | 0.517 | 16.73 | 8.65 | 27.406 |
| 110 | 103 | 43 | 312 | 330 | 32630 | 97344 | 34510 | 0.0010 | 0.539 | 15.06 | 8.11 | 30.950 |
| 120 | 114 | 54 | 338 | 360 | 38246 | 114244 | 40740 | 0.0011 | 0.567 | 13.89 | 7.87 | 30.246 |
| 130 | 121 | 61 | 379 | 390 | 48373 | 143641 | 49570 | 0.0006 | 0.584 | 12.71 | 7.42 | 40.524 |
| 140 | 144 | 84 | 432 | 420 | 63266 | 186624 | 60940 | 0.0004 | 0.637 | 11.59 | 7.38 | 47.958 |
| 150 | 167 | 107 | | | | | | | 0.686 | 10.48 | | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT –** Beech – **full preheat - test 1** | Ignition Time | 841 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | 33.88 | | |
| 20 | | | | | | | | | | 32.87 | 0.00 | |
| 30 | | | | | | | | | | 32.16 | 0.00 | |
| 40 | | | | | | | | | | 29.67 | 0.00 | |
| 50 | | | | | | | | | | 27.17 | 0.00 | |
| 60 | | | | | | | | | | 24.95 | 0.00 | |
| 70 | | | | | | | | | | 22.99 | 0.00 | |
| 80 | 842 | 0 | | | | | | | 0.999 | 21.03 | 21.01 | |
| 90 | 847 | 5 | 2542 | 270 | 2153982 | 6461764 | 228890 | 0.0018 | 1.000 | 18.88 | 18.88 | 23.484 |
| 100 | 853 | 11 | 2556 | 300 | 2177754 | 6533136 | 255690 | 0.0021 | 1.000 | 16.73 | 16.73 | 21.602 |
| 110 | 856 | 14 | 2569 | 330 | 2199945 | 6599761 | 282660 | 0.0028 | 1.000 | 15.06 | 15.06 | 18.772 |
| 120 | 860 | 18 | 2579 | 360 | 2217105 | 6651241 | 309550 | 0.0028 | 1.000 | 13.89 | 13.89 | 18.772 |
| 130 | 863 | 21 | 2588 | 390 | 2232594 | 6697744 | 336490 | 0.0039 | 1.000 | 12.71 | 12.71 | 15.916 |
| 140 | 865 | 23 | 2596 | 420 | 2246418 | 6739216 | 363490 | 0.0039 | 1.000 | 11.59 | 11.59 | 15.916 |
| 150 | 868 | 26 | 2605 | 450 | 2262033 | 6786025 | 390820 | 0.0028 | 1.000 | 10.48 | 10.48 | 18.772 |
| 160 | 872 | 30 | 2617 | 480 | 2282937 | 6848689 | 418810 | 0.0022 | 1.000 | 9.39 | 9.39 | 21.257 |
| 170 | 877 | 35 | 2632 | 510 | 2309202 | 6927424 | 447550 | 0.0018 | 1.000 | 8.33 | 8.33 | 23.484 |
| 180 | 883 | 41 | 2662 | 540 | 2362422 | 7086244 | 479410 | 0.0007 | 1.000 | 7.27 | 7.27 | 36.914 |
| 190 | 902 | 60 | 2706 | 570 | 2441534 | 7322436 | 514520 | 0.0005 | 1.000 | 6.55 | 6.55 | 43.589 |
| 200 | 921 | 79 | 2759 | 600 | 2537941 | 7612081 | 552140 | 0.0006 | 1.000 | 5.83 | 5.83 | 41.326 |
| 210 | 936 | 94 | 2809 | 630 | 2630641 | 7890481 | 590200 | 0.0006 | 1.000 | 5.17 | 5.17 | 39.377 |
| 220 | 952 | 110 | 2859 | 660 | 2725241 | 8173881 | 629330 | 0.0006 | 1.000 | 4.58 | 4.58 | 41.884 |
| 230 | 971 | 129 | 2906 | 690 | 2815434 | 8444836 | 668690 | 0.0006 | 1.000 | 3.99 | 3.99 | 39.703 |
| 240 | 983 | 141 | 2954 | 720 | 2909130 | 8726116 | 709250 | 0.0007 | 1.000 | 3.77 | 3.77 | 38.267 |
| 250 | 1000 | 158 | | | | | | | 1.000 | 3.54 | 3.54 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | $V_f$ | *F(t)* | $\dot{q}''_{.e}$ | $\dot{q}''_{.e}.F(t)$ | $1/\sqrt{V_f}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT** – Beech – **full preheat - test 2** | Ignition Time | 841 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | 847 | 0 | | | | | | | 1.000 | 21.03 | 21.03 | |
| 90 | 848 | 1 | 2545 | 270 | 2159013 | 6477025 | 229080 | 0.0064 | 1.000 | 18.88 | 18.88 | 12.472 |
| 100 | 850 | 3 | 2550 | 300 | 2167508 | 6502500 | 255040 | 0.0050 | 1.000 | 16.73 | 16.73 | 14.142 |
| 110 | 852 | 5 | 2555 | 330 | 2176013 | 6528025 | 281080 | 0.0064 | 1.000 | 15.06 | 15.06 | 12.472 |
| 120 | 853 | 6 | 2564 | 360 | 2191394 | 6574096 | 307750 | 0.0024 | 1.000 | 13.89 | 13.89 | 20.237 |
| 130 | 859 | 12 | 2575 | 390 | 2210259 | 6630625 | 334850 | 0.0020 | 1.000 | 12.71 | 12.71 | 22.509 |
| 140 | 863 | 16 | 2589 | 420 | 2234339 | 6702921 | 362540 | 0.0025 | 1.000 | 11.59 | 11.59 | 20.000 |
| 150 | 867 | 20 | 2604 | 450 | 2260334 | 6780816 | 390710 | 0.0018 | 1.000 | 10.48 | 10.48 | 23.741 |
| 160 | 874 | 27 | 2622 | 480 | 2291726 | 6874884 | 419660 | 0.0014 | 1.000 | 9.39 | 9.39 | 26.458 |
| 170 | 881 | 34 | 2647 | 510 | 2335701 | 7006609 | 450170 | 0.0011 | 1.000 | 8.33 | 8.33 | 30.246 |
| 180 | 892 | 45 | 2677 | 540 | 2389041 | 7166329 | 482090 | 0.0009 | 1.000 | 7.27 | 7.27 | 33.922 |
| 190 | 904 | 57 | 2709 | 570 | 2446449 | 7338681 | 514920 | 0.0009 | 1.000 | 6.55 | 6.55 | 32.514 |
| 200 | 913 | 66 | 2741 | 600 | 2504561 | 7513081 | 548400 | 0.0010 | 1.000 | 5.83 | 5.83 | 31.675 |
| 210 | 924 | 77 | 2770 | 630 | 2557834 | 7672900 | 581900 | 0.0010 | 1.000 | 5.17 | 5.17 | 31.675 |
| 220 | 933 | 86 | 2804 | 660 | 2621074 | 7862416 | 617110 | 0.0009 | 1.000 | 4.58 | 4.58 | 34.178 |
| 230 | 947 | 100 | 2847 | 690 | 2702387 | 8105409 | 655150 | 0.0006 | 1.000 | 3.99 | 3.99 | 41.445 |
| 240 | 967 | 120 | 2895 | 720 | 2794259 | 8381025 | 695140 | 0.0006 | 1.000 | 3.77 | 3.77 | 41.445 |
| 250 | 981 | 134 | 2944 | 750 | 2889466 | 8667136 | 736290 | 0.0007 | 1.000 | 3.54 | 3.54 | 38.086 |
| 260 | 996 | 149 | 2992 | 780 | 2984602 | 8952064 | 778260 | 0.0006 | 1.000 | 3.29 | 3.29 | 41.326 |
| 270 | 1015 | 168 | 3045 | 810 | 3091397 | 9272025 | 822530 | 0.0005 | 1.000 | 3.29 | 3.29 | 43.589 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 280 | 1034 | 187 | 3112 | 835 | 3229350 | 9684544 | 866525 | 0.0003 | 1.000 | 2.89 | 2.89 | 57.647 |
| 285 | 1063 | 216 | | | | | | | 1.000 | 2.89 | 2.89 | |
| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
| **RIFT** – Beech – **full preheat - test 3** | Ignition Time | 848 | | | | | | m/s | | kW/m² | | $(m/s)^{-0.5}$ |
| 10 | 0 | 0 | | | | | | | | | | |
| 20 | 0 | 0 | | | | | | | | | | |
| 30 | 0 | 0 | | | | | | | | | | |
| 40 | 0 | 0 | | | | | | | | | | |
| 50 | 0 | 0 | | | | | | | | | | |
| 60 | 0 | 0 | | | | | | | | | | |
| 70 | 0 | 0 | | | | | | | | | | |
| 80 | 0 | 0 | | | | | | | | | | |
| 90 | 0 | 0 | | | | | | | | | | |
| 100 | 0 | 0 | | | | | | | | | | |
| 110 | 848 | 0 | 1704 | 330 | 1450984 | 2901912 | 195940 | 0.0000 | 1.000 | 15.06 | 15.06 | 237.777 |
| 120 | 855.5 | 7.5 | 2567 | 360 | 2195753 | 6586922 | 308130 | 0.0013 | 1.000 | 13.89 | 13.89 | 27.386 |
| 130 | 863 | 15 | 2584 | 390 | 2224874 | 6674472 | 335950 | 0.0019 | 1.000 | 12.71 | 12.71 | 22.980 |
| 140 | 865 | 17 | 2606 | 420 | 2263878 | 6791236 | 364990 | 0.0011 | 1.000 | 11.59 | 11.59 | 29.740 |
| 150 | 878 | 30 | 2631 | 450 | 2307653 | 6922161 | 394880 | 0.0009 | 1.000 | 10.48 | 10.48 | 34.008 |
| 160 | 888 | 40 | 2666 | 480 | 2369428 | 7107556 | 426780 | 0.0009 | 1.000 | 9.39 | 9.39 | 33.212 |
| 170 | 900 | 52 | 2704 | 510 | 2437600 | 7311616 | 459960 | 0.0007 | 1.000 | 8.33 | 8.33 | 37.544 |
| 180 | 916 | 68 | 2754 | 540 | 2528900 | 7584516 | 496100 | 0.0005 | 1.000 | 7.27 | 7.27 | 43.770 |
| 190 | 938 | 90 | 2808 | 570 | 2629016 | 7884864 | 533900 | 0.0005 | 1.000 | 6.55 | 6.55 | 43.770 |
| 200 | 954 | 106 | 2872 | 600 | 2750360 | 8248384 | 574820 | 0.0005 | 1.000 | 5.83 | 5.83 | 46.257 |
| 210 | 980 | 132 | 2943 | 630 | 2888597 | 8661249 | 618580 | 0.0004 | 1.000 | 5.17 | 5.17 | 52.466 |
| 220 | 1009 | 161 | 3021 | 660 | 3043505 | 9126441 | 665140 | 0.0004 | 1.000 | 4.58 | 4.58 | 51.103 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 230 | 1032 | 184 | 3083 | 690 | 3168869 | 9504889 | 709420 | 0.0006 | 1.000 | 3.99 | 3.99 | 41.658 |
| 240 | 1042 | 194 | 3137 | 720 | 3280757 | 9840769 | 753190 | 0.0006 | 1.000 | 3.77 | 3.77 | 40.188 |
| 250 | 1063 | 215 | 3196 | 750 | 3406014 | 10214416 | 799490 | 0.0004 | 1.000 | 3.54 | 3.54 | 49.666 |
| 260 | 1091 | 243 | 3288 | 775 | 3606206 | 10810944 | 849920 | 0.0002 | 1.000 | 3.29 | 3.29 | 70.137 |
| 265 | 1134 | 286 | | | | | | | 1.000 | 3.29 | 3.29 | |

| *Flame Front Position x* | *Time to position x t (s)* | *time from ignition* | *Σt* | *Σx* | *Σ(t²)* | *Σ(t)²* | *Σ(t.x)* | *$V_f$* | *F(t)* | *$\dot{q}''_{.e}$* | *$\dot{q}''_{.e}.F(t)$* | *$1/\sqrt{V_f}$* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RIFT** – Beech – **full preheat - test 4** | Ignition Time | 841 | | | | | | m/s | | kW/m$^2$ | | (m/s)$^{-0.5}$ |
| 10 | | | | | | | | | | 33.88 | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 100 | 847 | 0 | 1696 | 300 | 1438210 | 2876416 | 178090 | 0.0000 | 1.000 | 16.73 | 16.73 | 237.628 |
| 110 | 849 | 2 | 2547 | 330 | 2162411 | 6487209 | 280210 | 0.0050 | 1.000 | 15.06 | 15.06 | 14.142 |
| 120 | 851 | 4 | 2553 | 360 | 2172611 | 6517809 | 306400 | 0.0050 | 1.000 | 13.89 | 13.89 | 14.142 |
| 130 | 853 | 6 | 2565 | 390 | 2193131 | 6579225 | 333550 | 0.0018 | 1.000 | 12.71 | 12.71 | 23.664 |
| 140 | 861 | 14 | 2587 | 420 | 2231059 | 6692569 | 362380 | 0.0010 | 1.000 | 11.59 | 11.59 | 31.833 |
| 150 | 873 | 26 | 2615 | 450 | 2279611 | 6838225 | 392450 | 0.0010 | 1.000 | 10.48 | 10.48 | 31.833 |
| 160 | 881 | 34 | 2649 | 480 | 2339315 | 7017201 | 424060 | 0.0009 | 1.000 | 9.39 | 9.39 | 33.575 |
| 170 | 895 | 48 | 2685 | 510 | 2403467 | 7209225 | 456730 | 0.0007 | 1.000 | 8.33 | 8.33 | 37.417 |
| 180 | 909 | 62 | 2731 | 540 | 2486635 | 7458361 | 491900 | 0.0006 | 1.000 | 7.27 | 7.27 | 40.104 |
| 190 | 927 | 80 | 2783 | 570 | 2582419 | 7745089 | 529150 | 0.0005 | 1.000 | 6.55 | 6.55 | 43.609 |
| 200 | 947 | 100 | 2849 | 600 | 2706763 | 8116801 | 570280 | 0.0004 | 1.000 | 5.83 | 5.83 | 49.216 |
| 210 | 975 | 128 | 2918 | 630 | 2839450 | 8514724 | 613270 | 0.0004 | 1.000 | 5.17 | 5.17 | 49.666 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 220 | 996 | 149 | 2997 | 660 | 2995317 | 8982009 | 659850 | 0.0004 | 1.000 | 4.58 | 4.58 | 50.759 |
| 230 | 1026 | 179 | 3073 | 690 | 3149293 | 9443329 | 707340 | 0.0004 | 1.000 | 3.99 | 3.99 | 52.513 |
| 240 | 1051 | 204 | 3152 | 720 | 3312902 | 9935104 | 756970 | 0.0004 | 1.000 | 3.77 | 3.77 | 49.501 |
| 250 | 1075 | 228 | 3225 | 750 | 3468027 | 10400625 | 806730 | 0.0004 | 1.000 | 3.54 | 3.54 | 48.990 |
| 260 | 1099 | 252 | | | | | | | 1.000 | 3.29 | 3.29 | |

# Appendix 5 Comparison with published results in the literature

| ***Plywood*** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | *b* $(s^{-0.5})$ | *t* (s)* | $T_{ig}$ *(°C)* | *h* $(kW/m^2K)$ | *kpc* $((kW/m^2k^2)^2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Radiata Pine | ISO | ISO 5657 | 17 | 13.75 | 4.6 | 0.048 | 432 | 352 | 0.041 | 0.93 | |
| Radiata Pine | LIFT | LIFT | 17 | 16.25 | 7.2 | 0.058 | 293 | 391 | 0.044 | 0.71 | |
| Radiata Pine | RIFT | RIFT | 17 | 16.25 | 9.9 | 0.061 | 273 | 391 | 0.043 | 0.66 | |
| | | | | | | | | | | | |
| Radiata Pine | Ngu, CK. 2002 | ISO 5657 | 20 | 12.00 | 7.2 | 0.034 | 870 | 321 | 0.040 | 1.76 | |
| Birch 9-ply | Azhakesan et al 1998 | Cone | | 10.7 | | 0.0387 | 655 | 386 | | 0.526 | |
| | | | | | | | | | | | |
| Birch faced | Jianmin, 1990 | Cone | 9 | 14 | | 0.051 | 383 | 389 | | 0.8106 | |
| "Ordinary" plywood | Nisted, 1991 | LIFT | 12 | 16.3 | | 0.0369 | 733 | 392 | | 1.7871 | |
| | | | | | | | | | | | |
| Japanese plywood - 8.1% MC | Fangrat et al, 1996 | Cone | 18 | | 11.5 | | | 328 | 0.038 | 0.762 | Janssens correlation |
| Japanese plywood -7.7%MC | Fangrat et al, 1996 | Cone | 12 | | 7.8 | | | 264 | 0.033 | 1.157 | Janssens correlation |
| Japanese plywood - 8.2%MC | Fangrat et al, 1996 | Cone | 9 | | 8.5 | | | 277 | 0.039 | 1.057 | Janssens correlation |
| Japanese plywood - 8.2%MC | Fangrat et al, 1996 | Cone | 5.5 | | 9.6 | | | 298 | 0.036 | 0.877 | Janssens correlation |
| US plywood | Fangrat et al, 1996 | Cone | 11.2 | | 14.5 | | | 372 | 0.028 | 0.334 | Janssens correlation |
| Douglas fir (NIST) | Fowell 1993 | LIFT | unspecified | 14.7 | | 0.0343 | 851 | 372 | | 1.89 | Round robin test – all Fowell's results used the same material but tested at different labs. |
| Douglas fir (UL) | Fowell 1993 | LIFT | unspecified | 17.5 | | 0.0383 | 681 | 408 | | 1.77 | |
| Douglas fir (Safety eng lab) | Fowell 1993 | LIFT | unspecified | 17.0 | | 0.032 | 974 | 402 | | 2.51 | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Douglas fir (NRCC) | Fowell 1993 | LIFT | unspecified | 14.0 | | 0.0337 | 880 | 363 | | 1.86 | LIFT protocol used for results. |
| Douglas fir | Dietenberger, 1995 ( c) | LIFT | 6.55 | 17 | 12.1 | 0.095 | | 335 | 0.048 | | Modified protocol & Janssens correlation |
| Douglas fir | Dietenberger, 1995 (a) | Unspecified | unspecified | | | | | 336 | | 0.254 | |
| Douglas fir -5 layers | Grexa, White and Dietenberger, 1996 | Cone | 11.5 | | 13.6 | | | 355 | 0.036 | 0.236 | Janssens correlation |
| Douglas fir -3 layers | Grexa, White and Dietenberger, 1996 | Cone | 12 | | 15.2 | | | 369 | 0.037 | 0.194 | Janssens correlation |
| Oak veneer ply - 5 layers | Grexa, White and Dietenberger, 1996 | Cone | 13 | | 8.9 | | | 279 | 0.030 | 0.465 | Janssens correlation |
| | | | | | | | | | | | |
| unspecified | Quintiere & Harkleroad, 1983 | LIFT | 6.3-12.7 | 16 | | | | 390 | | 0.46-0.54 | |
| | | | | | | | | | | | |
| **MDF** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | *b* $(s^{-0.5})$ | *t* (s)* | $T_{ig}$ *(°C)* | *h* $(kW/m^2K)$ | *kpc* $((kW/m^2k^2)^2$ | |
| "Customwood" MDF | ISO | ISO 5657 | 18 | 16.25 | 15.2 | 0.053 | 432 | 352 | 0.044 | 0.86 | |
| "Customwood" MDF | LIFT | LIFT | 18 | 16.25 | 14.7 | 0.047 | 293 | 391 | 0.044 | 1.10 | |
| "Customwood" MDF | RIFT | RIFT | 18 | 16.25 | 15.6 | 0.053 | 273 | 391 | 0.043 | 0.86 | |
| | Ngu, CK. 2002 | ISO 5657 | 20 | 13.50 | 12.9 | 0.043 | 870 | 348 | 0.039 | 1.04 | |
| | Asakasan etal 1998 | Cone | unspecified | | 7.7 | 0.046 | 486 | 334 | | 0.238 | |
| | Cleary & Quintiere, 1991 | Unspecified | unspecified | | | | | 361 | | 0.732 | |
| | Henderson, A. 1998 | Cone | unspecified | | 1.6 | | | 330 | | 1.377 | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

| **Melteca faced MDF** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | *b* ($s^{-0.5}$) | *t* (s)* | $T_{ig}$ *(°C)* | *h* ($kW/m^2K$) | *kpc* ($(kW/m^2k^2)^2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISO | ISO 5657 | 18 | 18.75 | 2.58 | 0.043 | 542 | 425 | 0.046 | 1.47 | |
| | LIFT | LIFT | 18 | 20.00 | 6.44 | 0.042 | 560 | 440 | 0.045 | 1.47 | |
| | RIFT | RIFT | 18 | 21.25 | - 1.06 | 0.051 | 382 | 454 | 0.047 | 1.07 | |
| | | | | | | | | | | | |
| **Melteca faced particle board** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²))* | *b* ($s^{-0.5}$) | *t* (s)* | $T_{ig}$ *(°C)* | *h* ($kW/m^2K$) | *kpc* ($(kW/m^2k^2)^2$ | |
| "Regal" brand shelving | ISO | ISO 5657 | 18 | 18.75 | 2.00 | 0.044 | 512 | 425 | 0.044 | 1.27 | |
| "Regal" brand shelving | RIFT | RIFT | 18 | 23.75 | 10.1 | 0.057 | 308 | 478 | 0.050 | 0.97 | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | Asakasan etal 1998 | Cone | unspecified | | 16.6 | 0.0402 | 576 | 463 | | 0.575 | |
| | Cleary & Quintiere, 1991 | LIFT | unspecified | | | | | 483 | | 0.804 | |
| | | | | | | | | | | | |
| **Hardboard** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | *b* ($s^{-0.5}$) | *t* (s)* | $T_{ig}$ *(°C)* | *h* ($kW/m^2K$) | *kpc* ($(kW/m^2k^2)^2$ | |
| | ISO | ISO 5657 | 5 | 11.25 | 0.59 | 0.033 | 944 | 307 | 0.039 | 1.83 | |
| | LIFT | LIFT | 5 | 17.50 | 2.17 | 0.052 | 375 | 409 | 0.043 | 0.88 | |
| | RIFT | RIFT | 5 | 11.25 | 2.57 | 0.032 | 977 | 307 | 0.037 | 1.67 | |
| | | | | | | | | | | | |
| | Azhakesan et al 1998 | Cone | unspecified | | 11.1 | 0.0384 | 665 | 392 | | 0.629 | |
| | Dietenberger, 1995 (b) | Cone | 6 | | 16.5 | | | 393 | 0.0389 | 0.277 | |
| | Dietenberger, 1995 (a) | Cone | unspecified | | | | | 281 | | 0.763 | |
| | Quintiere & Harkleroad, 1984 | LIFT | 6.35 | 10 | | | | 298 | | 1.87 | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quintiere & Harkleroad, 1984 | LIFT | 3.2 | 14 | | | | 365 | | 0.88 | |
| | | | | | | | | | | | |
| **NZ Beech** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | $b$ *($s^{-0.5}$)* | $t^*$ *(s)* | $T_{ig}$ *(°C)* | $h$ *($kW/m^2K$)* | $kpc$ *($(kW/m^2k^2)^2$* | |
| | ISO | ISO 5657 | 16 | 18.00 | 11.83 | 0.053 | 355 | 415 | 0.043 | 0.85 | |
| | LIFT | LIFT | 16 | 18.75 | 9.24 | 0.050 | 395 | 425 | 0.044 | 0.98 | |
| | RIFT | RIFT | 16 | 18.75 | 12.77 | 0.034 | 844 | 425 | 0.046 | 2.30 | |
| | Ngu, CK. 2002 | ISO 5657 | 20 | 12.00 | 11.14 | 0.025 | 1618 | 321.33 | 0.040 | 3.27 | |
| US Beech | Grexa, White Dietenberger, 1996 | Cone | 15 | | 13.7 | | | 358 | 0.0358 | 0.508 | |
| | | | | | | | | | | | |
| **Radiata Pine (Monterey Pine)** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | $b$ *($s^{-0.5}$)* | $t^*$ *(s)* | $T_{ig}$ *(°C)* | $h$ *($kW/m^2K$)* | $kpc$ *($(kW/m^2k^2)^2$* | |
| | ISO | ISO 5657 | 16 | 16.25 | 12.01 | 0.039 | 643 | 391 | 0.043 | 1.54 | |
| | LIFT | LIFT | 16 | 18.75 | 9.71 | 0.054 | 341 | 425 | 0.046 | 0.92 | |
| | RIFT | RIFT | 16 | 18.75 | 10.93 | 0.043 | 531 | 425 | 0.046 | 1.45 | |
| | | | | | | | | | | | |
| | Ngu, CK. 2002 | ISO 5657 | 20 | 15.50 | 7.78 | 0.047 | 460 | 380.17 | 0.043 | 1.08 | |
| 15% moisture content | Moghtaderi, B et al. 1997 | Cone | unspecified | | | | | | | 0.269 | In Babrauskas 2003 |
| 11% moisture content | Henderson, A. 1998 | Cone | unspecified | | 10.8 | | | 340 | | 0.593 | |

| **Rimu** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | *b* $(s^{-0.5})$ | *t* (s)* | $T_{ig}$ *(°C)* | *h* $(kW/m^2K)$ | *kpc* $((kW/m^2k^2)^2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISO | ISO 5657 | 16 | 18.00 | 12.75 | 0.050 | 397 | 415 | 0.045 | 1.03 | |
| | LIFT | LIFT | 16 | 18.50 | 9.62 | 0.050 | 395 | 422 | 0.046 | 1.06 | |
| | RIFT | RIFT | 16 | 21.25 | 13.88 | 0.047 | 462 | 454 | 0.049 | 1.41 | |
| | | | | | | | | | | | |
| | Ngu, CK. 2002 | ISO 5657 | 20 | 13.50 | 7.52 | 0.033 | 893 | 348 | 0.041 | 1.93 | |
| 10% MC | Henderson, A. 1998 | Cone | | | 10.4 | | | 355 | | 0.548 | In Babrauskas 2003 |
| Heart - 10%MC | Henderson, A. 1998 | Cone | | | 12.6 | | | 355 | | 0.548 | In Babrauskas 2003 |
| | | | | | | | | | | | |
| **Macrocarpa** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | *b* $(s^{-0.5})$ | *t* (s)* | $T_{ig}$ *(°C)* | *h* $(kW/m^2K)$ | *kpc* $((kW/m^2k^2)^2$ | |
| | ISO | ISO 5657 | 16 | 18.00 | 15.16 | 0.048 | 436 | 415 | 0.045 | 1.13 | |
| | LIFT | LIFT | 16 | 18.75 | 14.68 | 0.059 | 288 | 425 | 0.046 | 0.78 | |
| | RIFT | RIFT | 16 | 18.75 | 15.57 | 0.056 | 325 | 425 | 0.046 | 0.89 | |
| | Ngu, CK. 2002 | ISO 5657 | 20 | 15.50 | 12.89 | 0.055 | 337 | 380 | 0.043 | 0.79 | |
| | Henderson, A. 1998 | Cone | | | 11.1 | | | 402 | | 0.376 | |
| | | | | | | | | | | | |
| **Particle board** | *Source* | *Test* | *Thickness (mm)* | $\dot{q}''_{ig,\min}$ *(kW/m²)* | $\dot{q}''_{crit}$ *(kW/m²)* | *b* $(s^{-0.5})$ | *t* (s)* | $T_{ig}$ *(°C)* | *h* $(kW/m^2K)$ | *kpc* $((kW/m^2k^2)^2$ | |
| Pynefloor Rad. Pine flooring PB | Pynefloor ISO 5657 | ISO 5657 | 20 | 13.75 | 3.5 | 0.036 | 755 | 352 | 0.041 | 1.64 | |
| Pynefloor Rad. Pine flooring PB | Pynefloor LIFT | LIFT | 20 | 18.75 | 1.7 | 0.051 | 386 | 425 | 0.044 | 0.96 | |
| Pynefloor Rad. Pine flooring PB | Pynefloor RIFT | RIFT | 20 | 21.25 | 4.3 | 0.063 | 250 | 454 | 0.047 | 0.70 | |
| | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Superflake PB | Superflake ISO | ISO 5657 | 20 | 13.75 | 3.44 | 0.032 | 934 | 352 | 0.042 | 2.10 | |
| Superflake PB | Superflake RIFT | RIFT | 20 | 18.75 | 5.2 | 0.051 | 389 | 425 | 0.046 | 1.05 | |
| | Dietenberger and Grexa, 1999 | cone | | | | | | 257 | | 1.09 | |
| 7% MC - species unspecified | Janssens M, 1992 | LIFT | 13 | 20 | | | | 422 | 0.0431 | 0.277 | In Babrauskas 2003 |
| Douglas fir | Quintiere & Harkleroad, 1984 | LIFT | 12.7 | 16 | | | | 382 | | 0.94 | |
| Douglas Fir | Dillon, S & Hamins, A. 2003 | LIFT | 12.8 | 16 | | | | | | | In Babrauskas 2003 |
| | Babrauskas and Wetterlund (1999), | LIFT | 19 | 10 | | 0.0346 | 836 | 319 | 0.0338 | 1.215 | |
| | Cleary & Quintiere. 1991 | Unspecified | Unspecified | | | | | 405 | | 0.626 | |
| | Dietenberger, 1995 (a) | Unspecified | Unspecified | | | | | 529.7 | | 1.09 | |
| "US particle board" 7.1% MC | Fangrat et al, 1996 | Cone | 12.9 | | 3 | | | 145 | 0.02751 | 1.8 | |