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Advisory report regarding Wool Rich Carpets with respect to NCC 2022 Fire Hazard Properties

Technical advice report

Author: X. Lin and A. Webb
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Inquiries

Inquiries should be addressed to:

Author

CSIRO Infrastructure Technologies: Private bag 10, Clayton South, VIC, 3169, Australia

T (03) 9545 2222

Client

Carpet Institute of Australia
Suite 1.05, 493 St Kilda Road
Melbourne
Victoria 3004
Australia

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AUTHOR(S)		REVIEWED BY	AUTHORISED BY
X. Lin	A. Webb (Fire Safety Engineering)	N. White(Fire Safety Engineering)	N. White(Fire Safety Engineering)
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Contents

Executive summary

This report is an advisory report regarding wool rich carpets with respect to the NCC 2022 Volume 1 requirements for fire hazard properties of floor linings. In the context of this report wool rich means wool and nylon mix with up to 20 % nylon. The report sponsor is the Carpet Institute of Australia (CIAL).

This report:

- Summarises the available test evidence provided by the sponsor.
- Provides a statistical analysis to demonstrate that wool rich carpets similar to the tested specimens within a limited range of characteristics are likely to meet NCC DTS fire hazard property criteria with an acceptably high level of confidence.
- Objective is to reduce the quantity of testing that would otherwise have to be performed by the carpet industry while maintaining an appropriate level of life safety
- Concludes that there is sufficient evidence for a determination of compliance with NCC 2022 Clause C2D11 and Specification 7 fire hazard property requirements for floor linings, limited to the ranges of wool rich carpets specified within this report.

A statistical analysis was carried out on a body of data (414 tests) consisting of wool and wool rich wool/nylon blend carpets tested according to the fire test AS ISO 9239 Part 1-2003 to assess the likelihood of compliance with the NCC 2022 requirements for floor coverings for Class 2 to 9 buildings (NCC Volume 1, Specification 7). The statistical analysis was performed based on 414 test reports of tests to AS ISO 9239.1-2003 from NATA or ILAC accredited test laboratories. The criterion used was that a carpet of similar construction should have an estimated probability of failure to meet acceptance criteria stated by NCC 2022 Volume 1, Specification 7 Clause S7C3 for critical radiant heat flux (CRF) and smoke development rate (SDR) on each test of less than 0.1%. This was considered to provide a level of safety that will satisfy the Performance Requirements C1P4, of the NCC Volume 1 2022. Test reports for wool/nylon blend carpets where the wool content is of 80-100%, the Nylon content is a maximum of 20% and the Total Pile Mass (TPM) is 650g/m^2 or greater were the basis of the assessment.

Table A summarises whether, with 99.9% confidence, samples of various types of carpets, where the wool content is of 80-100%, can be expected to exceed the minimum value of Critical Radiant Flux (CRF) required by the NCC for floor covering materials. This depends on the underlay, the installation method and the weight (TPM). Table B is an indication of whether, with 99.9% confidence, those samples can be expected to have Smoke Development Rate (SDR) values below the maximum value required by the NCC for floor covering materials. The CRF and SDR values depend on the underlay and the weight (TPM). The types of carpets shown as achieving the CRF and SDR criteria are estimated to have a probability of 0.1% or less of failing the test at these levels.

No conclusion could be made regarding PVC backed carpet, FR Rubber underlay, SBR Rubber underlay, Synthetic Pad or carpet tiles. The above materials are excluded from the conclusions on expected CRF or SDR in this report.

Where a conclusion on the expected CRF or SDR value for a carpet system could not be drawn, or a product falls outside of the assessed product ranges in this reportthe carpet must be tested to AS ISO 9239 Part 1-2003 (separate to this report).

This report is valid for carpet of the above description manufactured by Brintons, Feltex Carpets, Godfrey Hirst Australia, Quest Carpets, Tuftmaster Carpets, Victoria Carpets, Cavalier Bremworth, EC Carpets, Prestige Carpets, Above Left, Rugs Carpets and Designs; Signature Floor Coverings, Chaparral Carpet Millsand Supertuft.

This report is based upon summary test data collated and supplied to CSIRO by CIAL. The data has been collated from test reports by test laboratories AWTA, APL, WRONZ and BTTG (UK). CSIRO has not received or reviewed the original test reports or certificates and has not provided any of the testing used as input data.

Table A: Summary of carpet types and TPM achieving Critical Radiant Flux (top table) with probability 99.9% and hence which can be considered to conform without further testing. Valid for 100% Wool carpets and Wool/Nylon blend carpets with a wool content not less than 80% wool and with a Total Pile Mass in the range 650g/m^2 to 2882g/m^2

Installation Method	Underlay	TPM (g/m^2)	
		CRF (kW/m^2) >2.2	CRF (kW/m^2) >4.5
Direct Stick	Nil	≥650	≥1290
Conventional	Nil	≥1330	≥2830
	SBR Latex	≥1270	≥2780
	Felt	≥1200	≥2710
	Rubber	≥1000	≥2510
	Reconstituted Textile	≥1110	≥2610
	Rebond Foam	≥1630	NA
Double Bond	SBR Latex	≥650	≥1870
	Reconstituted Textile		≥1800
	Rebond Foam	≥850	≥2340
	Crumb Rubber	≥920	≥2430

Table B: Summary of carpet types and TPM acheiing below the Smoke Development Rate with probability 99.9% and hence which can be considered to conform without further testing. Valid for 100% Wool carpets and Wool/Nylon blend carpets with a wool content not less than 80% wool and with a Total Pile Mass in the range 650g/m^2 to 2882g/m^2

Underlay	Smoke Development rate (SDR) <750 %.min
Rebond Foam	TPM ≥1020 g/m^2
Rubber	TPM ≥820 g/m^2
Nil	TPM ≥650 g/m^2
Reconstituted Textile	TPM ≥1330 g/m^2
SBR Latex	TPM ≥1030 g/m^2
Felt	TPM ≥1400 g/m^2
Crumb Rubber	TPM ≥1850 g/m^2

CSIRO concludes that is sufficient evidence for a determination of compliance with NCC 2022 Clause C2D11 and Specification 7 fire hazard property requirements for floor linings, limited to the ranges of wool rich carpets and manufacturer specified within Section 5.7 of this report. This conclusion is subject to the limtations stated in this report.

It is understood by CSIRO that determination of compliance with NCC 2022 Volume 1 Specification 7, Clause S7C3 is to be undertaken by the Authority Having Jurisdiction for any specific application.

Term of Validity

This assessment report will lapse on 1st May 2028. Should you wish CSIRO to re-examine this report with a view to extend the term of validity, apply to CSIRO six months before the date of expiry. CSIRO reserves the right at any time to amend or withdraw this assessment in the light of new knowledge.

1 Introduction

An assessment was originally undertaken by CSIRO, for the Carpet Institute of Australia Limited (CIAL) in 2007. The study examined the range of the fire performance of pure wool and wool rich carpet when tested in accordance with AS ISO 9239 Part 1 2003 [7]. In the context of this report wool rich means wool and nylon mix with up to 20 % nylon. Nylon is a commercial name of a polymer known as polyamide.

The report had been reissued several times to include new data and upon validity expiry (approximately every 5 years). This report has been issued as a new CSIRO report number as it includes significant changes including:

- a substantial number of new test reports included in the data set, and
- alignment with the revised National Construction Code (NCC) 2022.

This report:

- Summarises the available test evidence provided by the sponsor.
- Provides a statistical analysis to demonstrate that wool rich carpets similar to the tested specimens within a limited range of characteristics are likely to meet NCC DTS fire hazard property criteria with an acceptably high level of confidence.
- Objective is to reduce the quantity of testing that would otherwise have to be performed by the carpet industry while maintaining an appropriate level of life safety.
- Concludes that there is sufficient evidence for a determination of compliance with NCC 2022 Clause C2D11 and Specification 7 fire hazard property requirements for floor linings, limited to the ranges of wool rich carpets specified within this report.

Application: This report may be used as part of a submission to a regulatory body or an Authority Having Jurisdiction (AHJ) over a building compliance matter. It is understood by CSIRO that determination of compliance with NCC 2022 Volume 1 Specification 7, Clause S7C3 is to be undertaken by the Authority Having Jurisdiction for any specific application.

2 Scope of Work

2.1 General Description

The NCC requires certain materials and combinations of materials for use in buildings, other than single dwellings (Class 1 and 10 buildings), to be tested for fire performance compliance. A brief overview of the results of wool/nylon blend carpets where the wool content is of 80-100% and the Nylon content is a maximum of 20%, the Total Pile Mass (TPM) is >650g/m^2 indicates that all tests have achieved satisfactory results regardless of the underlay, construction type, installation technique or manufacturer.

Based on the above observation the scope of work was agreed as follows:

Stage 1. Original assessment

- Review the fire test data provided.
- Examine NCC framework and approach for the assessment.
- Assess the test data on a statistical basis to examine the variables and influence on the test results.
- Assess the limitations of the test data and the parameters within which the assessment is valid.
- Prepare a report concluding the assessment outcomes and limitations.
- Identify areas where further data is needed.
- Prepare a report concluding the assessment outcomes and limitations.

Stage 2. Update based on inclusion of further data.

- Revise the assessment including the additional data gathered.
- Prepare a report concluding the assessment outcomes and limitations. The conclusions are to state if the test data meets the relevant performance requirements of the NCC and the limitations of the work.

Test criteria assessed:

- DTS provisions stated within Clause S7C3 of Specification 7 and Table S7C3 of the NCC Volume 1 2022 (see Section 3.2.1 of this report)
- Analysis of Critical Radiant Flux (CRF) in the range of 1.2-2.2 kW/m^2 was excluded from this assessment due to insufficient test data in this range (all test data provided achieved CRF >2.2 kW/m^2

The *critical radiant flux* (CRF) and Smoke Development Rate (SDR) is determined by testing according to AS ISO 9239 Part 1 2003.

2.2 Report Basis

This report is based on:

(i) Originally, the NCC 2016, Building Code of Australia Volume 1, 2016 Edition Australian Building Codes Board2006;

(ii) CMMT(C)-2007 -120 (Revisions A to AF) Fire Engineering Assessment Of Wool Rich Carpets For Compliance To The Building Code Of Australia by R. Jarrett and A. Webb.

(iii) The reissued report has considered NCC 2022, Building Code of Australia Volume 1, 2022 Edition

(iv) Test data files provided by CIAL, as further described in this report; and

(v) Meetings with CIAL at various times.

3 Objectives of the Study

3.1 General Objectives

In simple terms, the objective of the study is:

1. Assess if there is sufficient evidence for a determination of compliance with NCC 2022 Clause C2D11 and Specification 7 fire hazard property requirements for floor linings, limited to the ranges of wool rich carpets specified within this report.
2. Provide above assessment based on a combination of available test data and statisitical analysis to reduce the quantity of testing that would otherwise have to be performed by the carpet industry while maintaining an appropriate level of life safety.

3.2 NCC Requirements

3.2.1 DEEMED-TO-SATISFY REQUIREMENTS

Clause S7C3 of Specification 7 of the NCC states:

A floor material or floor covering must have—

(a) a critical radiant flux not less than that listed in Table S7C3; and

(b) in a building not protected by a sprinkler system (other than a FPAA101D or FPAA101H system) complying with Specification 17, a maximum smoke development rate of 750 percent-minutes; and

(c) a group number complying with Clause 6(b), for any portion of the floor covering that is continued more than 150 mm up a wall

Item (c) is not addressed in this report. This report excludes carpet used as wall lining more than 150 mm up a wall, or ceiling lining. Table S7C3 is reproduced below.

Critical radiant flux (CRF) - defined by the NCC is "*the critical heat flux at extinguishment (CHF in kW/m2) as determined by AS ISO 9239.1:2003*". Critical heat flux at extinguishment (CHF) as defined by AS ISO 9239.1:2003 is "*incident heat flux (kW/m2) at the surface of a specimen at the point where the flame ceases to advance and may subsequently go out. The heat flux value reported is based on interpolations of measurements with a non-combustible calibration board". Note the* AS ISO 9239.1:2003 value of *heat flux after the test period of 30 min (HF-30), is not suitable for NCC compliance."*

The data provided to CSIRO used the term CRFFlameout to describe the critical radiant flux data. The term CRFFlameout was used throughout the analysis and, where used in this report, is synonymous with critical radiant flux.

***Smoke development rate* (SDR)** – The NCC defines smoke development rate as "*The development rate for smoke as determined by testing flooring materials in accordance with AS ISO 9239.1:2003*". The term "smoke development rate (SDR)" is not a defined term in AS ISO 9239.1:2003. However, AS ISO 9239.1:2003 Annex A defines the method for measuring and reporting the maximum light attenuation (expressed as 0-100%), the curve of the light attenuation over time (expressed as a graph of % light attenuation vs time over duration of test) and the integrated smoke value calculated as the integral of the smoke obscuration over the testing time (area under the graph of % light attenuation vs time over duration of test, expressed as %.min). Smoke development rate (SDR) is taken to be the integral of % light attenuation over the testing time and has units of percent x minutes (%.minute) or (percentage-minute).

The data provided to CSIRO used the term SmokeFlameout to describe the smoke development rate data. The term SmokeFlameout was used throughout the analysis and ,where used in this report, is synonymous with maximum smoke development rate.

The NCC references the 2003 version of AS ISO 9239.1 which is an identical adoption of ISO 9239.1:2002. The latest version of the ISO standard is 2010.

Carpet used on walls, ceilings or as other building elements must comply with other Sections of the NCC and appropriate test methods.

The critical radiant flux is a level of imposed radiant heat below which sustained burning does not continue, hence a high value of CRF pertains to a more onerous requirement or a better forming material. This reports assess the likelyt performance to the 4.5 and 2.2 kW/m^2. The analysis does not look at confidence of products achieving >1.2 kW/m^2 NCC acceptance criteria.

NCC 2022 Volume 1, Specification 7 Table S7C3 Critical Radiant Flux (CHF in kw/m^2) of floor linings and floor coverings.

Class of Building	**General**		**Fire-isolated exits and fire control rooms**
	Building **not** fitted with a sprinkler system (other than a FPAA101D or FPAA101H system) complying with Specification 17	Building fitted with a sprinkler system (other than a FPAA101D or FPAA101H system) complying with Specification 17	
Class 2,3,5,6,7,8 or 9b - excluding accommodation for the aged	2.2	1.2	2.2
Class 3 Accommodation for the aged	4.5	2.2	4.5
Class 9a Patient care areas Areas other than patient care areas	4.5 2.2	2.2 1.2	4.5 4.5
Class 9b Auditorium or audience seating used mainly for indoor swimming or ice skating	1.2 2.2	1.2 1.2	2.2 2.2
Class 9b Auditorium or audience seating used mainly for other sports or multi-purpose functions.	2.2	1.2	2.2
Class 9c Resident use area	N/A	2.2	4.5
Class 9c Areas other than resident use areas	N/A	1.2	4.5

3.2.2 NCC PERFORMANCE REQUIREMENTS

The relevant performance requirement of the NCC 2022 Volume 1 is C1P4, which states:

> *C1P4 Safe conditions for evacuation*
>
> *To maintain tenable conditions during an occupant evacuation, a material and an assembly must, to the degree necessary, resist the spread of fire and limit the generation of smoke and heat, and any toxic gases likely to be produced, appropriate to—*
>
> *(a) the evacuation time; and*
>
> *(b) the number, mobility and other characteristics of occupants; and*
>
> *(c) the function or use of the building; and*
>
> *(d) any active fire safety systems installed in the building.*

3.3 Limitations

- The conclusions of this assessment report may be used to directly assess the fire performance under such conditions, but it should be recognised that a single test method will not provide a full assessment of the fire hazard under all fire conditions.
- Due of the nature of fire testing inherent variability in test procedures; materials and methods of construction; and installation may lead to variations in performance between products of similar construction.
- This assessment report does not provide an endorsement by CSIRO of the actual products supplied to the industry. This report can therefore only relate to the actual prototype test specimens, testing conditions and methodology described in the supporting data, and does not imply any performance abilities of construction of subsequent manufacture.
- This assessment is based on information and experience available at the time of preparation. The test standards and the assessment methodologies are the subject of review and improvement and it is recommended that this report is reviewed on, or before, the stated expiry date.
- The information contained in this assessment report shall not be used for the assessment of variations other than those stated in the conclusions above. The assessment is valid provided no modifications are made to the systems detailed in this report. All details of construction should be consistent with the requirements stated in the relevant test reports and all referenced documents.
- This report does not assess the use of carpets as a building material other than use as a floor covering. The NCC requires testing of materials in accordance with various test methods for use as wall and ceiling linings and as other elements.
- This report does not apply to those situations where a person is involved, either accidentally or intentionally, with the fire ignition or early stages of development of a fire; building fire safety systems are not generally designed to protect such persons.
- This report does not encompass situations that involve fire hazards outside the range normally

encountered in buildings, such as storage of flammable liquids, processing of industrial chemicals or handling of explosive materials.

- Conventional building design can only provide limited protection against malicious attack. Large scale arson, large quantities of deliberately introduced accelerants, terrorism and multiple ignition sources has not been considered. These events can potentially overwhelm some fire safety systems.
- The scope of the assessment is limited to compliance with NCC matters such as property protection (other than protection of adjoining property), business interruption, public perception, environmental impacts and broader community issues (such as loss of a major employer, impact on tourism etc.) have not been considered.
- The methods of analyses, input data and acceptance criteria are appropriate for the application being considered in this report only.
- The goal of 'absolute' or '100%' safety is not attainable and there will always be a finite risk of injury, death or property damage. Fire and its consequent effects on people and property are both complex and variable. Thus, a fire safety system may not effectively cope with all possible scenarios. The intent of regulations and this report related to health, safety and amenity in buildings is to mitigate risks to a level accepted by the community.
- AHJ's and peer reviewers should not use information provided in this report for review for any purposes other than for checking compliance of a carpet type for the specific building under consideration and lodgement with prescribed bodies. All practitioners should treat all fire safety engineering reports, peer review reports, test data research reports and similar supporting documents as confidential, unless permission is granted for broader distribution or use.
- Test data utilised in this report has been used with the express permission of the owner of the data.
- This report is based upon summary test data collated and supplied to CSIRO by CIAL as summaries in excel format. The data has been collated from test reports by test laboratories AWTA, APL, WRONZ and BTTG (UK). CSIRO has not received or reviewed the original test reports or certificates The statistical models developed in this report are dependant upon the test data given by the client at "face value".
- The assessment is based on the typical construction configuration of carpets in use at this time. The assessment does not cover the issues that may arise for manufacturing techniques and application methods that may arise in the future.
- Weights and thicknesses of carpet underlays, backings and adhesives were not available as part of the data set provided by Carpet Institute of Australia. The CSIRO analysis and the conclusions drawn from the analysis therefore assume that the test data provided are representative of the range of values used in normal practice for these weights and thicknesses. Total Pile Mass (TPM) and brief material names/descriptions were provided for each test in the dataset.

4 Methodology

The methodology is to be carried out within the framework provided by the NCC Section A. The Australian Fire Engineering Guidelines and the Engineers Australia – Society of Fire Safety Code of Practice for Fire Safety Design, Certification and Peer Review [5] have also been consulted.

4.1 Evidence of suitability

Section A5G3 requires *evidence to support that the use of a material, product, form of construction or design meets a Performance Requirement or a Deemed-to-Satisfy Provision may be in the form of any one, or any combination of the following:*

(d) A report issued by an Accredited Testing Laboratory that—

(i) demonstrates that a material, product or form of construction fulfils specific requirements of the NCC; and
(ii) sets out the tests the material, product or form of construction has been subjected to and the results of those tests and any other relevant information that has been relied upon to demonstrate it fulfils specific requirements of the NCC.

4.2 Compliance with the Performance Requirements

As stipulated in NCC Volume 1 2022 Clause A2G1, it will be shown that compliance with the Performance Requirements will be satisfied by *A Deemed-to-Satisfy Solution.*

This report:

- Summarises the available DTS test evidence provided by the sponso
- Provides a statistical analysis to demonstrate that wool rich carpets which vary from the tested specimens within a limited range of characteristics are likely to meet NCC DTS fire hazard property criteria with an acceptably high level of confidence.
- Ojective is to reduce the quantity of testing that would otherwise have to be performed by the carpet industry while maintaining an appropriate level of life safety.

4.3 Analysis Methods

The verification method will be the following:

- Review the fire test data provided.
- Set an acceptance criteria based on statistical confidence intervals.
- Assess the test data on a statistical basis to examine the variables and influence on the test results.
- Assess the limitations of the test data and the parameters within which the assessment is valid.
- Conclude parameters of carpet construction within which the acceptable confidence limits are achieved.

4.4 Acceptance Criteria

The following acceptance criteria shall be used to evaluate the statistical analysis on variations from DTS test specimens.

4.4.1 GENERAL STATISTICAL METHODOLOGY

At the outset, it is necessary to make a clear distinction between the current method by which a carpet passes (or does not pass) the test, and the proposed method.

1. In order for wool and wool-rich carpets to be approved as complying with the Deemed to Satisfy Requirements in the NCC, they currently need to pass both of the requirements for CRF and, for buildings not protected by a compliant sprinkler system, SDR as determined in the AS ISO 9239.1 test.
2. In order for wool and wool-rich carpets of a particular class to be approved as complying with the Performance Requirements in the NCC, a representative set of carpets of that class need to provide test results which collectively indicate that any carpet of that class would have a chance of less than, say, 0.001 of failing either of the two test requirements.

Thus, "acceptance" for an individual carpet would then come from one of two routes – that it either passes the tests itself, or that it is identified as belonging to a "class" of carpets which have been collectively demonstrated in the past to have a high probability of passing the required tests.

The implications of the second route are

1. It is necessary to define a set of "classes" of carpet, where all carpets within that "class" would be expected to have similar properties on both tests,
2. These "classes" need to be determined through a judicious combination of the knowledge of carpet experts and statistical analysis designed to detect whether carpets within a proposed class are "similar enough".
3. It is necessary to have a representative sample from each proposed class in order to determine both its mean response to each test and the degree of variability in those test results, in order to determine the likely range of values for the test in relation to the specification limit.

The statistical analysis that is undertaken here is then centred on two aspects. The first is the identification and confirmation of the distinct classes and their properties on each test. The second is the determination of the level of confidence with which we can say that a future carpet from that class will pass the test.

4.4.2 CONFIDENCE INTERVALS

Each carpet tested either passes or fails the test. However, in each case, the outcome of the test is a specific value and this value is subject to random variation arising from a number of sources. For example, the description of the Test method has an Annex B which gives the precision of the test method, in terms of its repeatability and reproducibility, obtained from a round robin exercise using 13 laboratories.

Repeatability provides the standard deviation (SD) related to the test method (same carpet, same laboratory, same operator), while reproducibility is a standard deviation where the same carpet is tested in a different laboratory by a different operator.

For example, for a Wool/Polyamide carpet (80/20), the mean Critical Radiant Flux (CRF)) is given as 7.8 kW/m^2, and the reproducibility SD is given as 1.5 kW/m^2. Given that this is based on 13 laboratories, we assume that the SD has 12 degrees of freedom. Based on this, we can assess the probability of a carpet in this class having a CRF of less than 4.5 kW/m^2. This is given by:

$$\mathrm{Prob}(X < 4.5) = \mathrm{Prob}\left\{ t_{12} < \frac{4.5 - 7.8}{1.5\sqrt{1 + 1/13}} \right\} = 0.028$$

Here, the symbol t_{12} represents a t-distribution with 12 degrees of freedom and tables or computer software can be used to determine the probability that the value of t_{12} is less than the number calculated. There is a sense in which this is likely to under-estimate the probability of failure. It is based on a single wool/polyamide carpet sent to a number of laboratories for testing. The variation (SD=1.5) is solely about the variation in the test method and does not include a component for the fact that different wool/polyamide carpets will differ from each other. If we had tested a variety of such carpets, then the mean might well be different from 4.5, in either direction, but it is likely that the SD of 1.5 is an under-estimate. A larger value for the SD would lead to a higher probability of failing the test.

In manufacturing, control limits for a product are generally set at 3 standard deviations either side of the average value for that product [6]. A process is said to be in control if the control limits sit inside the specification limits. In the carpet situation, the specification limit is one-sided, so the process of producing the carpet will be in control provided the mean of the test results is more than three times the estimated standard deviation away from the specification limit for that test. Provided the data for that class (or some suitable transformation of the data) can be shown to be close to a Normal distribution, then the probability of a test failing when it involves carpet from that class of carpets will then be less than 0.00135 or 1 in 740. To reduce this probability to 0.001 requires 3.09 standard deviations [6].

For comparison purposes the operational reliability of fire protection systems such as sprinklers, smoke detection and compartmentation have been estimated as in the range of 72 to 99.5% reliability [3].

Because different classes of carpets will have different means, and possibly different standard deviations, it is necessary to undertake an analysis of the data across a large number of tests to see whether in fact different classes have different means and to decide which classes of carpets (in combination with underlay) can be considered to be "in control". The underlay has a major influence on the CRF and SDR values.

5 Carpet Characteristics

Sections 5.1 to 5.6 below provide background information on l general carpet types, materials and manufacturing methods.

Section 5.7 clarifies the carpet types analysed in this report.

5.1 Carpet Manufacturing Methods

Carpet is manufactured in a number of ways. The most commonly used methods are:

- Tufting
- Weaving - Axminster and Wilton
- Modular carpet (tiles)
- Other: e.g. bonded, flocked, etc.

Tufted and woven carpets are sold for both domestic and commercial installations. Woven carpets traditionally form the high end of the market, while tufted carpets span the market from economy styles to high end. Modular carpets are used mainly in commercial installations.

The fibres used in the carpet pile yarns are usually wool, nylon, polypropylene, polyester or acrylic or a combination of these with wool and wool rich carpets forming about 30% of the market.

5.2 Carpet Styles

Tufted carpets were originally produced in loop pile, and in coarse or wider gauge qualities. Despite the efficient production methods, and good wear performance of the tufted carpets, they had little consumer appeal compared to traditional Axminster and Wilton carpets, which could display various degrees of patterning, and which were available in cut pile styles.

In the 1960's major moves were made in simple patterning devices and the introduction of more suitable fibres and yarns. Possibly the most attractive feature of tufted was and is the production efficiencies and speed.

Tufted carpet manufacturers have gone a considerable way towards being able to produce pattern carpet indistinguishable from woven Axminster and Wilton carpets.

Today, tufted carpet has about 90% of the Australian market. The market for carpet is split approximately as show in Table 5-1.

Table 5-1: Australian carpet market by style

Tufted	90%
Woven	5%
Modular (Carpet Tiles) and Other	5%

5.3 Types of Carpet Manufacture

5.3.1 WEAVING

The pile yarns are held between warp (lengthwise) yarns of Jute, cotton and/or synthetic fibres and weft (crosswise) yarns of jute and/or synthetic. The production looms use complex versions of the standard over and under weaving technique.

The backing produced by the weaving process is sufficient to stabilise the carpet and no additional backing is applied although on occasions a latex size is applied to stiffen the carpet.

Wilton

Wilton carpet manufacture consists of many painstaking and laborious processes. Several loom types are used to manufacture a variety of carpet constructions where single frame Wilton and Jacquard and multi frame Wilton produce the woven carpet. Wilton carpet is typically 100% wool or 80% wool/20% nylon.

Axminster

Axminster carpets are woven in two distinctly different types of looms; these are the spool Axminster and the gripper Axminster. Axminster is typically 100% wool or 80% wool/20% nylon.

5.3.2 TUFTING

Modern tufting machines produce carpet in excess of the traditional 366cm (12 feet) in width, so that even after shrinkage from the backcoating process, the carpet can be trimmed to produce a final width of 366cm. A great variety of needle gauges, pile heights and pile styles are created by modifying the tufting process. Needles are fitted into the needle bar, which is driven by the eccentric shaft in a reciprocating fashion. The needles extend across the width of the tufter, the number depending on the gauge and width of the machine. A tufted carpet consists of a number of layers:

- The wear layer – the pile surface of the carpet. This can vary from 2.5mm to 16mm above the backing depending on the quality of the carpet being produced. In the range covered by this application, the pile thickness is likely to be 5mm or more.
- The primary backing – this is normally a sheet of woven polypropylene fabric of weight approx 115 g/m^2. It can also be a layer of non-woven polyester of similar density.
- The secondary backing – this is a layer of woven jute or woven polyethylene of weight approx $75 g/m^2$ and provides dimensional stability to the carpet.
- Latex – this is the "glue" that holds the layers together. It is applied between the primary and secondary backings and heat cured. It consists of filled (Calcium Carbonate, $CaCO_3$ or similar) latex of total density of approximately 820 g/m^2.

5.4 Pile Types

Carpet pile can be either left as the loop that is formed during the weaving/tufting operation or the loops can be cut to provide a softer feel to the surface.

Loop pile is used primarily in commercial installations and low end residential installations where appearance retention is more important than underfoot feel. Cut pile tends to be more applicable in residential installations and high end commercial installations where underfoot feel has greater importance.

There are also a number of combinations of cut and loop pile, provided mainly for aesthetic reasons. Hi/Lo Loop and Multi-Level Loop are essentially the same, differing only in the number of levels of loops in the blend. Similarly Cut/Loop and Multi-Level Cut/Loop differ only in degree and position of the cut and loop piles in the design.

Axminster carpet is always cut pile while Wilton carpet and Tufted carpet can be either cut or loop pile.

5.5 Carpet Installation

Carpet is installed using one of three techniques.

- Conventional Installation
- Direct Stick Installation
- Double Bond Installation

These three techniques are used in a number of different circumstances which can be described as set out below.

5.5.1 CONVENTIONAL INSTALLATION

Carpet is laid loose over an underlay and secured to the floor at the edges of the room using wooden strips with nail points protruding upwards to grip the carpet. The carpet is stretched into place to provide a taught surface on which to walk. Conventionally installed carpet is generally installed over an underlay of some description. See the attached table for details.

Conventionally installed carpets are used in most installation situations, both domestic and commercial. It is used across the whole range of carpet qualities from inexpensive to luxury. Woven carpets are usually a conventional installation.

5.5.2 DIRECT STICK INSTALLATION

Carpet is stuck directly to the floor without underlay using a water based adhesive applied at a rate of about 3.5-4 m^2/l.

This type of installation is primarily used for low end installations in spec. built flats and units to cheapen the installation cost or in commercial installations where the carpet is installed for aesthetic reasons and foot comfort is of less importance. Typically there is only one type/brand of glue used in the industry.

Double bond Installation

Underlay is adhered to the floor using a peelable adhesive at a rate of about 10 m^2/l (typically there is only one type/brand of glue used in the industry) and then the carpet is stuck to the underlay using a non-peelable adhesive similar to that used in direct stick applications at about 2.5-3 m^2/l (typically there is only one type/brand of glue used in the industry).

Double Bond installation is primarily used in commercial installations where foot comfort is important and the substrate is in good condition (e.g. over concrete floors).

5.6 Underlay Types

The underlay types in common use in Australia are listed in Table 5-2. These are the combinations of Material and Installation Method which are of interest.

Table 5-2: Underlay types in use in Australia

	Domestic	Commercial
Double Bond	Rarely used	*SBR Latex – 5mm & 1400 g/m^2* *Reconstituted Textile (Fibre) – 6-7 mm & 900-1100 g/m^2* Rebond Foam – 5mm & 170 kg/m^3
Conventional Installation	Felt – 10-14mm & 1200 g/m^2 Rebond Foam – 8mm & 69 kg/m^3 Rubber – 7-9.5mm & 1700-3200 g/m^2. Crumb rubber 7 mm & Density 400 kgs/m^3 SBR Latex is not used.	Felt – 12-17mm & 1400-1800g/m^2 Rebond Foam – 7mm & 120 kg/m^3 Reconstituted Textile (Fibre) – 9mm & 900 g/m^2 Rubber – 7-8mm & 1700-2360 g/m^2 Crumb rubber 7 mm & Density 400 kgs/m^3 SBR Latex is not used.

5.7 Carpet Type Assessed

The carpet assessed in this report and covered by the conclusions in this report are:

5.7.1 MANUFACTURER

This report is valid for carpet of the below description manufactured by

- Brintons,
- Feltex Carpets,
- Godfrey Hirst Australia,
- Quest Carpets,
- Tuftmaster Carpets,
- Victoria Carpets,
- Cavalier Bremworth,
- EC Carpets,

- Prestige Carpets,
- Above Left,
- Rugs Carpets and Designs;
- Signature Floor Coverings;
- Chaparral Carpet Mills and
- Supertuft.

Tascot test data is included but the company has subsequently closed.

5.7.2 PILE WEIGHT

The pile weight or Total Pile Mass (TPM) which is the mass of fibre not including the backing or underlay:

- 100% wool carpets of TPM of between 650g/m^2 and 2882 g/m^2; and
- Wool/nylon blend carpets where the wool content is a minimum of 80% and the Nylon content is a maximum of 20%, with TPM of between 800g/m^2 and 2823 g/m^2;

5.7.3 PILE TYPE

Cut, cut/loop and loop carpet.

5.7.4 UNDERLAY

The types of underlay:

- Rubber up to 9.5mm & 1700-3200 g/m^2,
- Reconstituted textile/fibre up to 14mm & 1550 g/m^2,
- No underlay (NIL),
- SBR Latex of up to 7mm thick and 2200 g/m^2,
- Rebond foam of up to 8mm and/or 120kg/m^3,
- Felt of up to 17mm thick,
- Crumb rubber manufactured from Granulated Recycled Tyre Rubber and bonded with Natural Rubber Latex Binder Density 400 kgs/m3, 7 mm thick.

5.7.5 MANUFACTURE TYPE

Woven (Wilton and Axminster) and Tufted carpet.

Backing Type

Types of backing include:

- The primary backing –a sheet of woven polypropylene or non-woven polyester fabric of weight approx 115 g/m^2.
- The secondary backing –woven jute or woven polyethylene of weight approx 75g/m^2.

- Latex – adhesive applied between the primary and secondary backings and heat cured of total density of approximately 820 g/m^2.

Application Method

Carpet is installed using one of three techniques.

- Conventional Installation
- Direct Stick Installation
- Double Bond Installation

6 The Data

From April 2020 to November 2021, CIAL has provided CSIRO up to seven iterations of carpet fire testing data/results, see Table 6-1.

Table 6-1: Carpet Fire Testing Data/Reports provided by CIAL.

Date
07/04/2020
19/07/2020
26/02/2021
05/03/2021
10/03/2021
30/06/2021
21/10/2021
01/11/2021 (Final)
27/04/2023 (edits)

The data sets are described in Section 6.1. This report is based on the final data set received.

In what follows, the various factors and variables used in the analysis will be represented with a capital letter (e.g. Weight, Pile and Installation Method). In addition, the levels which these factors are assigned in the data file (such as SBR Latex, Rebond Foam, Reconstituted Textile) are used as abbreviations in the analysis.

6.1 Data Sets

The final data analysis covered two data files. These were received on 26 April 2023 and contain all testing data used in this report. The data files are:

- Copy of CSIRO Study Data -Wool Only 111121 FINAL marked with edits CIAL.xlsx
- Copy of CSIRO Study-Wool Nylon-111121 FINAL marked with edits CIAL.xlsx

The first of these contains 333 rows, corresponding to 332 test results for carpets which are all 100% Wool, plus a note row at 279.

The second file contains 87 rows, corresponding to 87 test results for carpets which are 80–95% Wool and 20–5% Nylon.

All tests were carried out by four accredited laboratories: (1) AWTA, (2) APL, (3) WRONZ and (4) BTTG (UK). Results have been given back to the Carpet Institute (CIAL). CIAL has summarised all test results into spreadsheets which have been provided to CSIRO for analysis. In these spreadsheets, the manufacturer's identity has been protected by replacing them with a numbered code. The number of test results provided to CSIRO in the data sets are summarised by category in Table 6-2 and Table 6-3.

Table 6-2: Number of test results provided by Description of pile categories and manufacturing methods. (Note, FR Rubber, SBR Rubber and Synthetic Pad are excluded).

	Wool only			Wool / Nylon		
↓Pile ManufMethod →	**Tufted**	**Woven**	**Total**	**Tufted**	**Woven**	**Total**
Cut	69	5	74	11	44	55
Cut/Loop	8	0	8	0	1	1
Loop	223	14	237	28	2	30
Total	**300**	**19**	**319**	**39**	**47**	**86**

Table 6-3: Number of test results provided by Description of underlay categories and installation methods;

Install Underlay	Wool Only				Wool/Nylon			
	Conv	**Direct Stick**	**Double Bond**	**Total**	**Conv**	**Direct Stick**	**Double Bond**	**Total**
Nil	5	39	0	44	6	24	0	30
Crumb Rubber	0	0	5	5	0	0	1	1
Felt	11	0	0	11	7	0	0	7
FR Rubber (*)	5	0	0	5				
Rebond Foam	81	0	5	86	10	0	5	15
ReconFibre	0	0	1	1				
ReconTextile	45	0	0	45	8	0	5	13
Rubber	78	0	3	81	4	0	0	4
SBR Latex	6	0	40	46	0	0	16	16
SBR Rubber (*)	0	0	3	3				
Synthetic Pad (*)					0	0	1	1
Total	**231**	**39**	**57**	**327**	**35**	**24**	**28**	**87**

Note, those underlays marked with (*) are removed from the analysis.

We noted earlier that we need to identify "classes" of carpets and then find the properties of those classes. Clearly, "classes" with small number of samples will have properties which are very poorly estimated and it will not then be possible to make reliable estimates of the parameters. There are several ways of dealing with this:

1. *Consolidation*: Knowledge of the carpet industry could be used to assert that certain categories are highly likely to be very similar to other categories. This then has the dual effect of reducing the number of combinations, while at the same time increasing the number of tests in particular classes.
2. *Exclusion*: There are some combinations which are not seen as being similar to other carpets and

which are so poorly represented that there is no chance of reliably determining their properties. In such cases, we will indicate that these should be tested individually as they arise.

3. *A fortiori*: Where there is a strong argument that a small class should be "not worse than" some other larger class, and where that is substantiated from the limited data available, we might conclude that the small class can be assumed to have similar properties (or better) to the larger class and might therefore not need additional testing.
4. *Further testing*: Where a class of carpets is relatively poorly represented but is considered to be an important class, recommendations may be made to obtain tests on further samples so that reliable estimates can be determined.

The judgments made at this stage, arising out of Table 6-2 and Table 6-3 are:

- For Underlay, there is only one Synthetic Pad sample and three SBR Rubber samples. these two underlays are excluded from the study and must be tested on an individual basis.
- Reconstituted Fibre is the same as Reconstituted Textile, so merge the classes.
- The DirectStick method is applied only with no underlay (marked as “Nil”, “NIL” or “None”) is regarded as the sameclass.
- The FRRubber (FR=Fire Retardant) is a small class with only 5 samples, but should have CRF properties superior to the Rubber class but smoke values may be higher, hence, excluded from the analysis.
- It was noted earlier that SBR Latex underlay is typically not used with Conventional installation, only with Double Bond. Yet there are six samples here which are classified as SBR Latex underlay with Conventional installation. These have been left in the data set.

This reduced the number of Wool samples to 319 and the number of Wool/Nylon samples to 86, making a total sample of 405 for the analysis. Even with these decisions, there were some combinations here with very small numbers of samples. One way to improve the numbers is to try analysing the data as a single data set, where we allow for differences related to the %Wool in the carpets, which will now range from 80% to 100%, as a separate parameter. Thus, the two datasets will be combined as a single one for the analysis with their underlays sorted based on the number of test samples, see Table 6-4.

Table 6-4: Number of test reports by underlay categories and installation methods for analysis.

	Number of reports - Wool Rich			
↓ Underlay Install →	**Conventional**	**Direct Stick**	**Double Bond**	**Total**
Rebond Foam	91		11	102
Rubber	82		3	85
Nil	11	63		74
SBR Latex	6		55	61
Reconstituded Textile	54		6	60
Felt	17			17
Crumb Rubber			6	6
Total	**261**	**63**	**81**	**405**

7 Analysis

7.1 CRF (Critical Radiant Flux)

7.1.1 DETERMINING THE EFFECTS OF THE COVARIATES

A statistical analysis of the 405 values of CRF was conducted with all the covariates included. This first analysis shows that there are significant effects related to Underlay, Install, Weight and ManufID, and there is also a significant difference between Conventional, DoubleBond and Direct Stick installation. The carpet Pile is less significant (P=0.0136). Same to ManufMethod (Tufted vs Woven) (P=0.0193). The %Wool (given that all are at least 80% Wool) and the test laboratories (Lab) are not significant with P=0.26 and P=0.32, respectively.

Since ManufID has 14 levels (companies) with only four manufacturers (ManufID 15 (baseline), 4, 7, 20) are significant, include it in the model will make it very complicated. Hence, the ManufID has been excluded in the modelling.

After deleting Pile, ManufID, ManufMethod, %Wool and Lab from the list of factors considered, the full analysis (lmC4) shows the following.

- The largest differences are related to Underlay (P<0.0001). The largest class, Rebond Foam, is used as the baseline. The major difference is due to the Direct Stick method which has no Underlay at all and which has CRF 2.177 (SD=0.47) higher than Rebond Foam. Both Rubber and Reconstituted Textile Underlays have CRF significantly different from Rebond Foam.
- Double Bond has CRF higher than Conventional installation by 1.290 (SD=0.296).
- A linear increase in CRF with Weight is evident (t=8.26, P<0.0001).

The analysis was followed by production of a Normal Probability plot (see Table 7-1). The fact that this is close to a straight line is indicative that the data is behaving close to a Normal distribution, thus justifying the calculations of tail probabilities needed later on in this analysis.

Within the 405 samples used in the analysis, there are a total of 23 test samples with their CRF values below 4.5kw/m^2. In Figure 7.2, those samples with their CRF below 4.5 can be shown by the dots (with conventional installation) or triangles (with double bond or direct stick) located below the black line (4.5 kw/m^2). No test data provided had a CRF values below 2.2kw/m^2. No test data provided had a SDR values above 750 %.min.

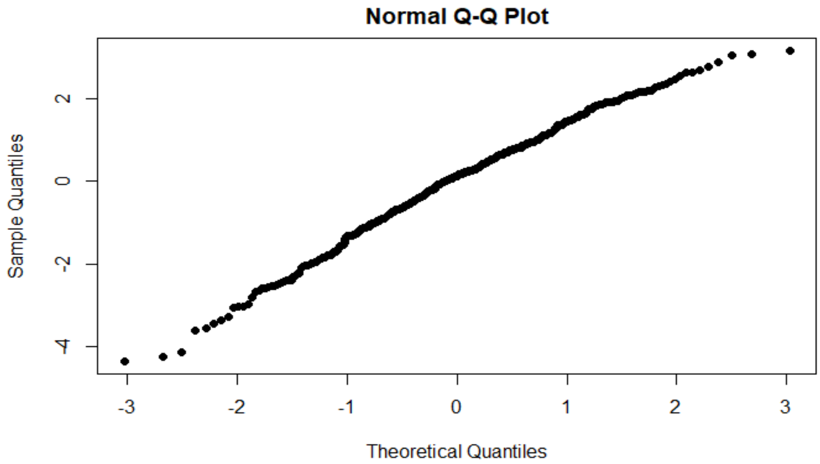

Figure 7.1: Normal probability plot for 405 residuals from analysis of CRF values.

Table 7-1: Formulae for CRF for major classes, for Loop pile and Conventional installation. Additional terms are shown that need to be added in for DoubleBond or Direct Stick installation.

Material	Formulae (model=lmC4)	Installation
Rebond Foam (102)	6.393+1.549×W Double Bond: +1.404	Conventional (91) Double Bond (11)
Rubber (85)	7.371+1.549×W Double Bond: +1. 404	Conventional (82) Double Bond (3)
Nil (74)	7.044+1.549×W Direct Stick: +2.185	Conventional (11) Direct Stick (63)
SBRLatex (61)	7.038+1.549×W Double Bond: +1. 404	Conventional (6) Double Bond (55)
Reconstituted Textile (60)	7.217+1.549×W Double Bond: +1. 404	Conventional (54) Double Bond (6)
Felt (17)	7.175+1.549×W	Conventional (17)
Crumb Rubber (6)	6.546+1.549×W Double Bond: +1. 404	Double Bond (6)

The formulae thus obtained for CRF are summarised in Table 7-1. In producing this table, we have converted the Weight (g/m^2) to a centred variable W=(Weight-1440.2)/1000. The value of this is that the constants given refer to carpets with an average weight of 1440.2 g/m^2. The slope then shows how the CRF increases for each 1000 g/m^2 increase in the weight of the carpet.

7.1.2 PRESENTATION OF THE DATA

The final model here is comprehensive. We have a different line for each of the seven Underlay classes, based on the Underlay and the Weight, but then we have further adjustments to those models based on the Installation Method.

We can reduce the number considered as follows:

- For Rebond Foam, Rubber, SBR Latex and Reconstituted Textile underlays, we have either Conventional or DoubleBond installation.
- For Nil underlay, we have either Conventional or DirectStick installation.
- For Felt underlay, we only have Conventional installation.
- For Crumb Rubber underlay, we only have Double Bond installation.
- The data can now be plotted, with the fitted lines in place.

To make it easier to see, we break these up into three graphs (see Figure 7.2), using the same axes for each:

- The top graph (a) shows all the data for Rebond Foam and Rubber with four lines are fitted models. The two black lines are for Rebond Foam with the solid line for Conventional installation, while the dashed line for Double Bond installation. Same to Rubber showing with red lines.
- The middle graph (b) shows the data and fitted lines for DirectStick (means no underlay) and SBRLatex. Again, there are four lines with two for each types of underlays. Light green lines for Nil underlay and blue lines are for SBRLatex. Note Nil and SBR latex conventional are very close and appear as a single line.
- The bottom graph (c) shows the data and fitted lines for Reconstituted Textile, Felt and Crumb Rubber underlays. Four lines are plotted with two light blue lines for the Reconstituted Textile (for Conventional and Double Bond) while one magenta line for Felt (for Conventional) and one yellow line Crumb Rubber (for Double Bond). Note Reconstituted textile and felt conventional are very close and appear as a single line.

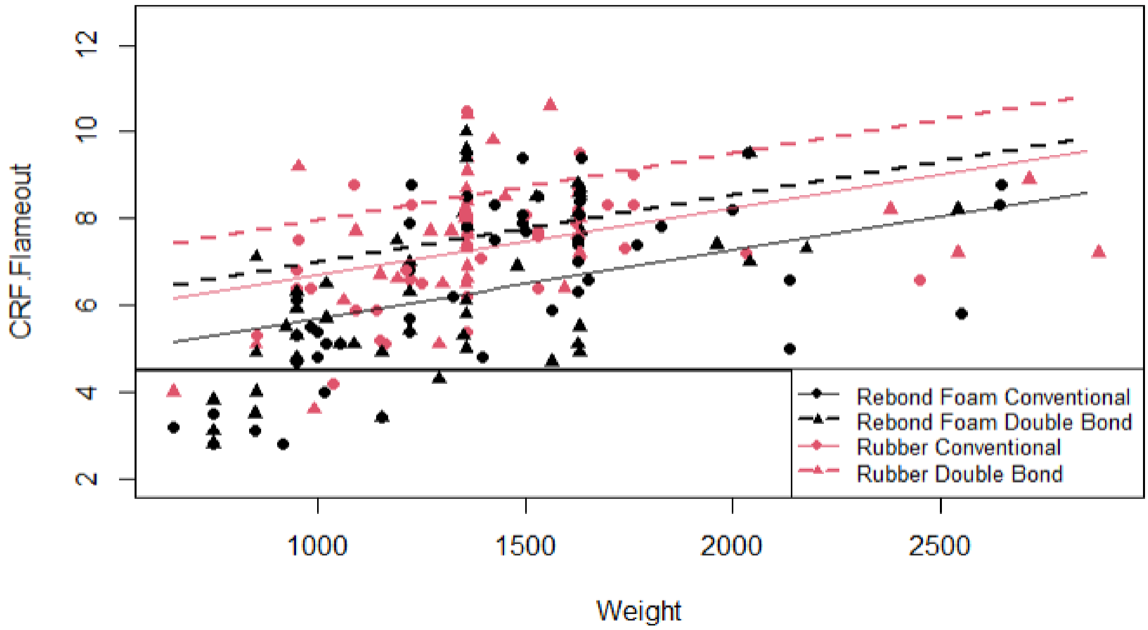

Figure 7.2 (a)

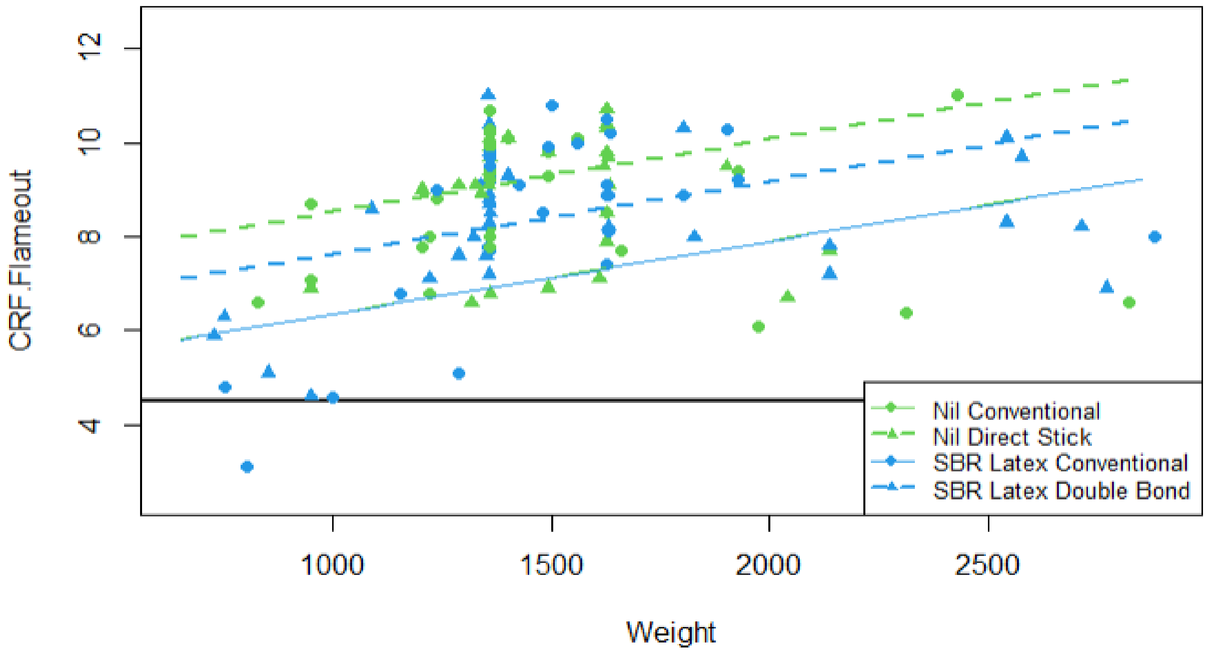

Figure 7.2 (b)

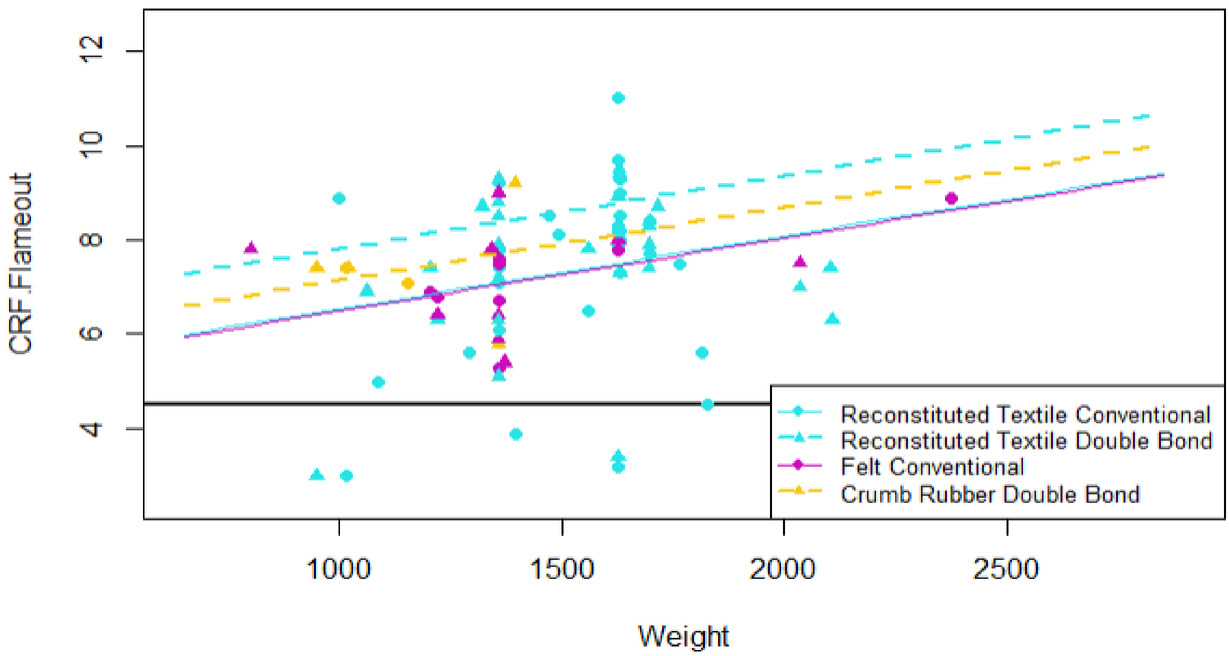

Figure 7.2 (c)

Figure 7.2: CRF vs Weight under a variety of different conditions (underlays and Installation methods).

7.1.3 DETERMINING FAILURE RATES

As we did earlier, we need to determine the probability of a sample falling below the specification limit of 4.5 kW/m^2. The calculations are now more complex, because Weight is a continuous random variable. As a result, the probability of a sample failing will vary with Weight and the levels of Underlay and Installation Method. The graphs below will show the 95% prediction intervals for the fitted lines. This means that there is a 2.5% chance that a future value will lie below the lower prediction interval line for each of the seven Underlay classes. We will show seven graphs, one for each of the underlay classes, with the 95% confidence limits.

These 95% two-sided prediction intervals are defined as

$$(a_i+bW) \pm\ 1.966 \sqrt{(s^2+V)},$$

where a_i is the intercept for each of the seven levels of Underlay and b is the slope for that particular Underlay, as given in the formulae above. W is the weight at which the calculation is being done and V=Var(a_i+bW) is the variance of the predicted CRF at weight W. The multiplier 1.966 is $t_{(.975,\ 395)}$, the upper 97.5% point of a t-distribution with 395 degrees of freedom and s^2 is the residual variance from the model, given by 2.058. This formula provides the prediction intervals plotted in the graphs.

These can be turned around to give the probability of being below the specification limit of 4.5 kW/m^2 by finding the value of α for which

$$(a_i+bW) \pm\ t_{(\alpha,395)} \sqrt{(s^2+V)} = 4.5.$$

When this is solved for α, it provides the (left) tail probability in a t-distribution with 395 degrees of freedom when the t-value is given by

$$\{4.5 - (a_i+bW)\} / \sqrt{(s^2+V)}.$$

This then provides the second in each pair of graphs, in which we plot the probability of failing the test, as a function of Underlay, Weight and, where appropriate, Installation Method. In some cases, a further graph is given, showing the probability of being below the weaker specification limit of 2.2 kW/m^2. We now describe each of these in turn.

Rebond Foam Underlay

There are 101 samples with Rebond Foam as the underlay. The graphs (a) and (b) of Figure 7.3 show that for Conventional installation, Rebond Foam fails the test at 4.5kW/m^2 at well above the 0.1% (or 0.001) requirements. For Double Bond installation, the Rebond Foam underlay achieves the requirements at 4.5kW/m^2 at weights above 2340 g/m^2 (see (d)).

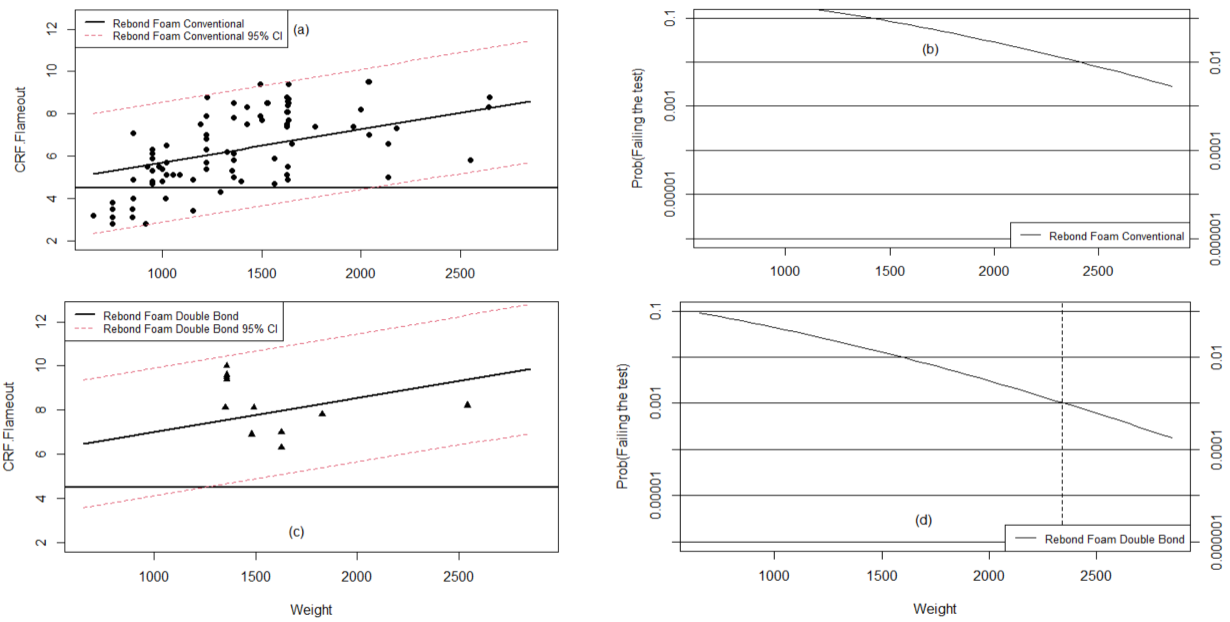

Figure 7.3: CRF vs Weight for Rebond Foam and implied probability of failing the CRF test at 4.5 kW/m^2.

For 2.2kW/m^2 requirments, Rebond Foam fails the test with Conventional installation when weight is below 1630 g/m^2 (see the left graph of Figure 7.4). For Double Bond installation, Rebond Foam passes the test when the weight is above 850 g/m^2 (see the right graph of Figure 7.4).

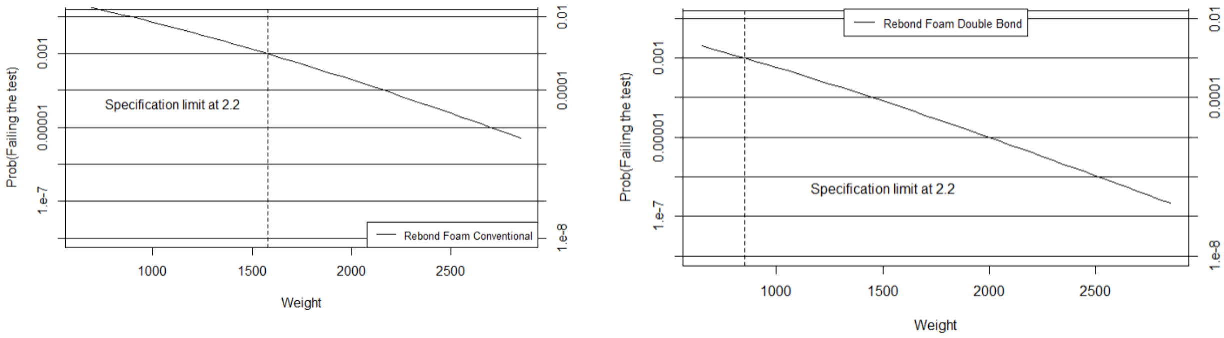

Figure 7.4: Implied probability of failing the CRF test at 2.2 kW/m^2 for Rebond Foam with Conventional (left graph) or DoubleBond (right graph) installation methods.

Summary: For Rebond Foam underlay with Conventional installation, the carpets meet the test requirements at the specification limit of 2.2 kW/m^2 when the weight is above 1630 g/m^2, but do not meet them at 4.5 kW/m^2. For Double Bond installation, the requirements are met to 2.2 kW/m^2 when weight is greater than 850 g/m^2, while at 4.5 kW/m^2, they are met by its weight greater than 2340 g/m^2.

We note that this confirms the comment in the earlier report that "if the results are in close agreement with the average of the current samples, then Rebond Foam underlay would be satisfactory against the specification limit of 2.2 kW/m^2 but not against the specification limit of 4.5 kW/m^2."

Rubber Underlay

The solid line in the left graph of Figure 7.5 represents the prediction line, while the dotted red lines represent the 95% prediction confidence intervals for future values. We see, for example, the lower red dotted line crosses the specification of 4.5 kW/m^2 at around 1400 g/m^2. This implies that, at 1400 g/m^{2,} there is about a 2.5% chance that a future test with Rubber underlay with Conventional installation will fail the test. The right graph reverses the calculation and shows the probability of failing the test for each Weight. For example, we see that the solid line has a 1% probability of failing the test at a weight about 1760 g/m^2 but increases as the weight decreases. The line crosses 0.1% probability of failing at 2510 g/m^2 for specification of 4.5 kW/m^2.

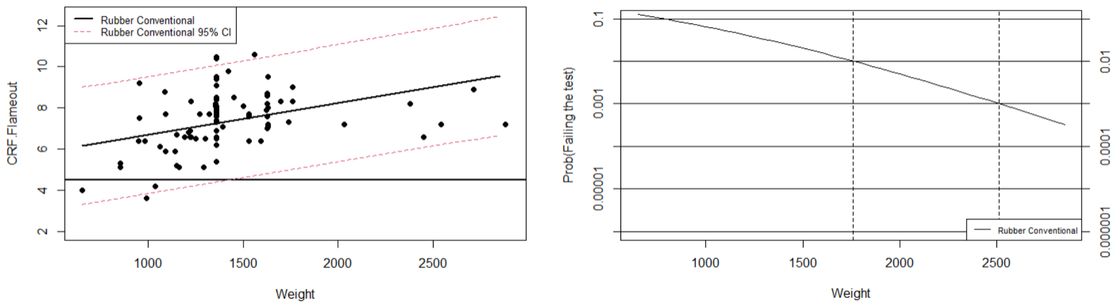

Figure 7.5: CRF vs Weight for Rubber (with Conventional installation) wih 95% prediction intervals (left graph) ; and probability of failing the CRF test at 4.5kW/m^2 (right graph).

The graph (see Figure 7.6) on probability of failure was repeated here with a revised specification limit of 2.2 kW/m^2. The following graph shows that this underlay now fails the test for weights above 1000 g/m^2 with a probability of much less than 0.1%.

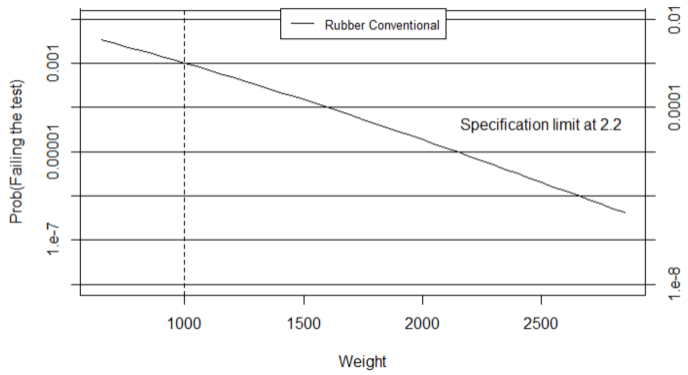

Figure 7.6: Implied probability of failing the CRF test at 2.2 kW/m^2 for Rubber Conventional installation.

Since there are only 3 samples for Rubber underlay with Double Bond installation, it is too few samples for the analysis results to be reliable.

Summary: For Rubber underlay installed by the Conventional method, samples have a probability of less than 0.1% of failing the test with the specification limit at 2.2 kW/m^2 for the carpet weight above 1000 g/m^2. However, with the specification limit raised to 4.5 kW/m^2, we can only reliably assert that the probability of failing the test is less than 0.1% for its weight greater than 2510 g/m^2. There is no conclusion can be made for Rubber underlay with Double Bond installation due to only three samples.

Nil Underlay

For Nil underlay installed with Conevntional method, the lower prediction confidence limit (2.5%) cuts through the 4.5 kW/m^2 specification limit (see (a) of Figure 7.7). This is confirmed in the (b) graph, the probabilities of failure below 0.1% only for carpet weight being above 2830 g/m^2. For Nil underlay installed with Direct Stick method (see (c)) with respect to the the 4.5 kW/m^2 specification limit, the probabilities of failure below 0.1% when carpet weight is above 1290 g/m^2 (see (d)).

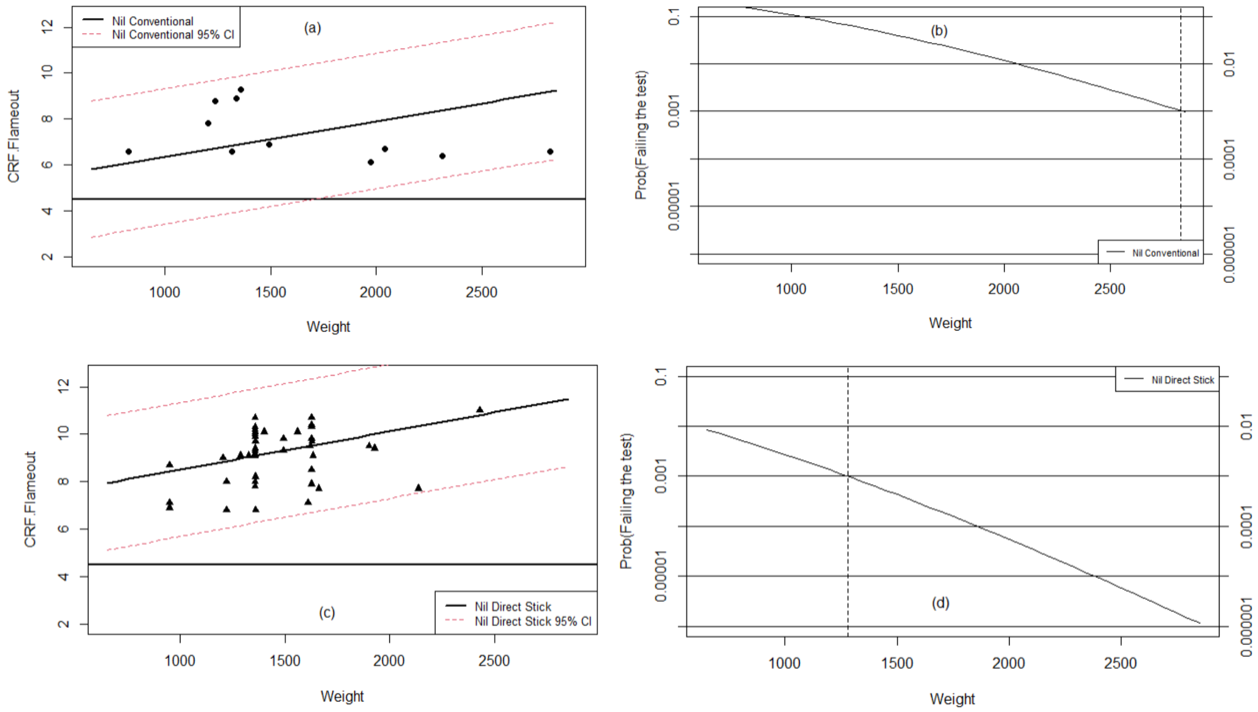

Figure 7.7: CRF vs Weight for Direct Stick and probability of failing the CRF test at 4.5 kW/m^2.

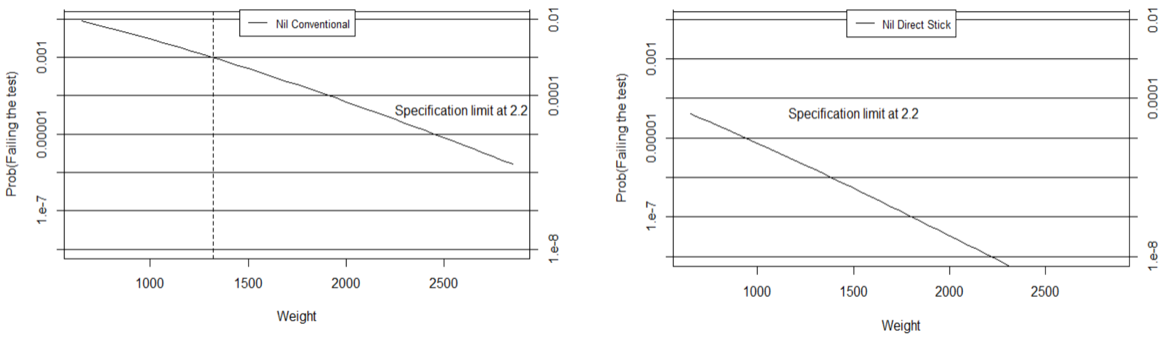

Figure 7.8: Probability of failing the CRF test at 2.2 kW/m^2; Nil underlay with Conventional (left graph) and Direct Stick (right graph) installation methods.

With the 2.2 kW/m^2 specification limit, for Nil underlay with Conventional installation method the probabilities of failure below 0.1% when weight is greater than 1330 g/m^2 (see the left graph of Figure 7.8) For Direct Stick method, the probabilities of failure is well below 0.1% (see the right graph of Figure 7.8) for all weight above 650 g/m^2 which is based on the sample minimum weight.

Summary: For Direct Stick carpets without an underlay, there is less than a 0.1% chance of failing the test at the specification limit of 4.5 kW/m^2, when the weight is greater than 1290 g/m^2. For specification limit of 2.2 kW/m^2, all Direct Stick carpets have less than a 0.1% chance of failing the test at the specification limit for weight above 650 g/m^2. For the case of no underlay with Conventional installation method, the probabilities of failing specification limit of 2.2 kW/m^2 is less than 0.1% for weight above 1330 g/m^2. For the specification limit of 4.5 kW/m^2, only weight above 2830 g/m^2 has a less than 0.1% chance of failing the test.

SBR Latex Underlay

For SBR Latex underlay, with Conventional installation, there are only six samples with its lower prediction confidence line overlap the specification limit of 4.5 kW/m^2 at mid weights (see (a) of Figure 7.9). This is confirmed in (b) graph, where the probabilities of failure at above 0.1% (0.001) for weights below 2780. With Double Bond installation (see (c)), the probabilities of failure of the specification limit of 4.5 kW/m^2 are below 0.1% for weights above 1870 g/m^2 (see (d)).

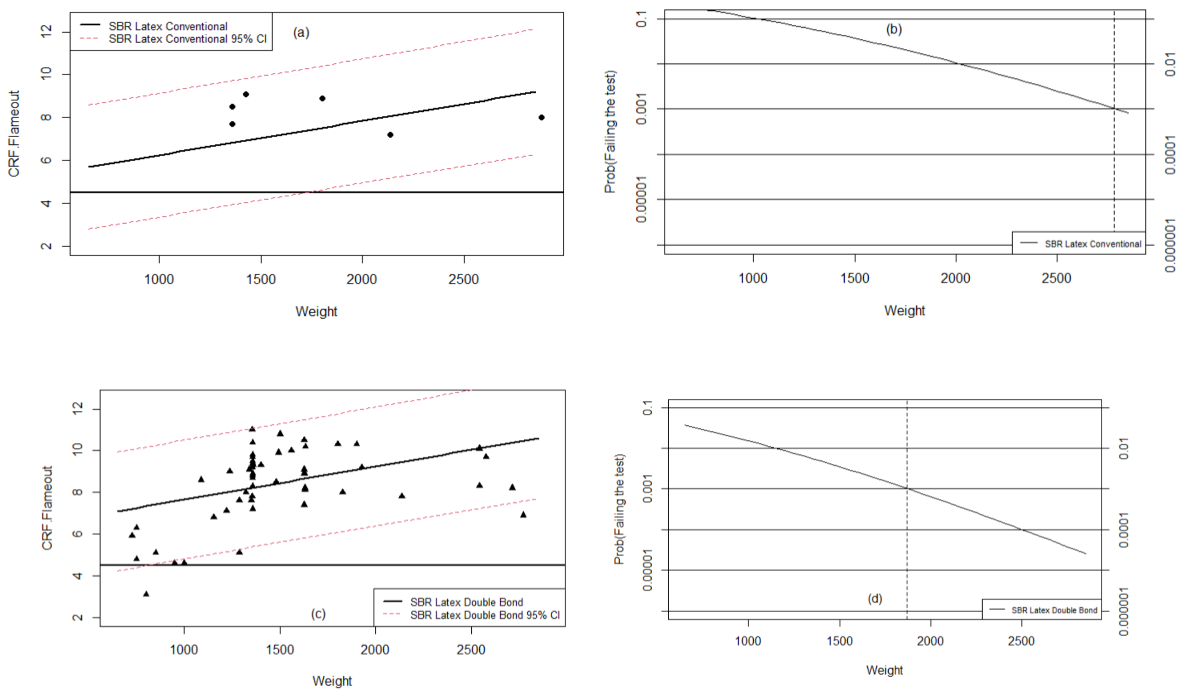

Figure 7.9: CRF vs Weight for SBRLatex and probability of failing the CRF test at 4.5 kW/m^2.

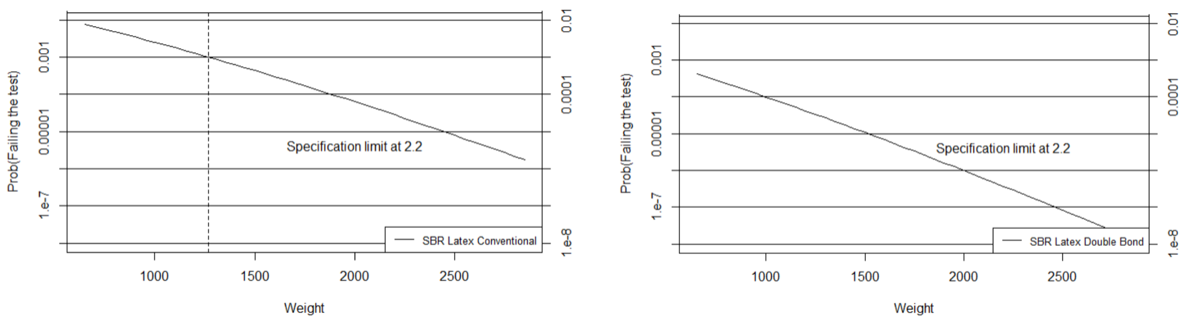

Figure 7.10: Probability of failing the CRF test at 2.2 kW/m^2; SBR Latex with Conventional (left graph) and Double Bond (right graph) installation methods.

The calculations were repeated with the specification limit lowered to 2.2 kW/m^2, see Figure 7.10, and it shows that the probability of failing the test at this level is below 0.01% for weights above 1270 g/m^2 for Conventional installation (the left graph) and all weights for Double Bond installation (the right graph).

Summary: For SBR Latex underlay, there is only a 0.1% chance (or less) of failing the test at the specification limit of 2.2 kW/m^2 for weights above 1270 g/m^2 with Conventional installation but for all weights (above 650 g/m^2) with Double Bond installation. When the specification limit is raised to 4.5 kW/m^2, the probability of failing the test is less than 0.1% to weights above 2780 g/m^2 with Conventional installation, where for Double Bond installation, it is for weights above 1870 g/m^2.

Reconstituted Textile Underlay

For Reconstitude Textile underlay with the specification limit of 4.5 kW/m^2, we show two pairs of graphs (Figure 7.11). The first pair (see (a) and (b)) is for the Conventional installation, while the second pair (see (c) and (d)) is for the DoubleBond. We note that there are only 6 samples for DoubleBond – only five appear in the graph with one sample point is actually two samples with identical values of CRF (both were "11", the maximum value that can be obtained). For Conventional installation, the probabilities of failing is less len 0.1% only when weight is above 2610 g/m^2 (see (b)), while for Double Bond it is above 1800 g/m^2 (see (d)).

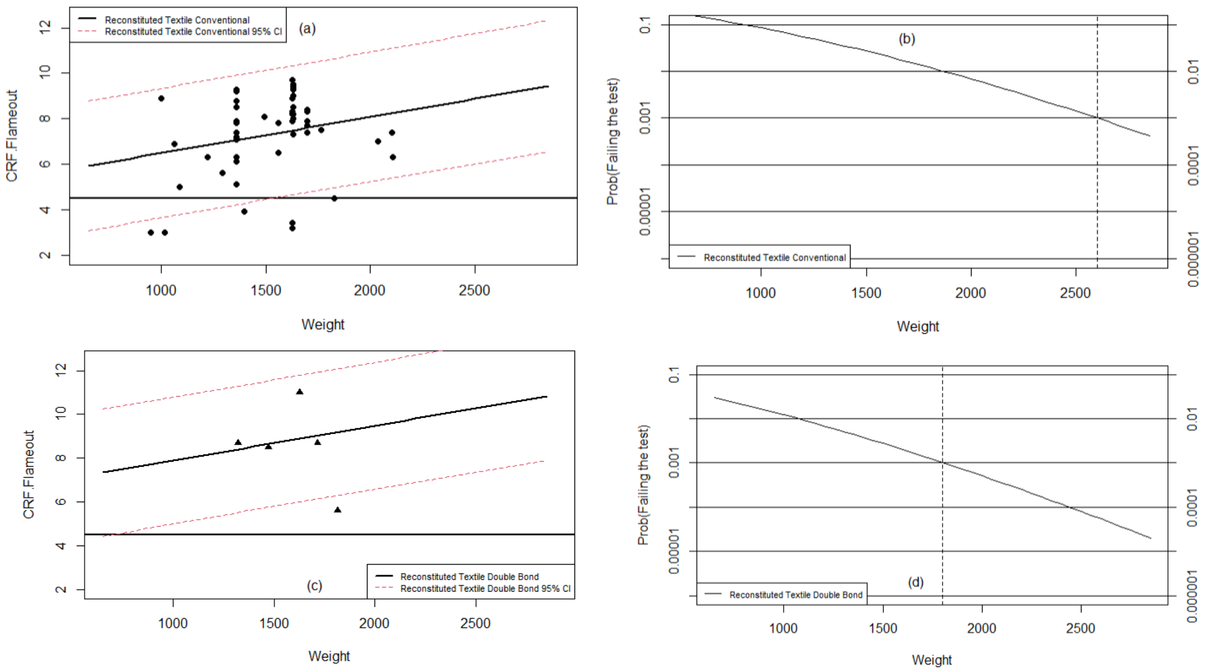

Figure 7.11: CRF vs Weight for Reconstituted Textile with 95% prediction intervals (Conventional (a) and Double Bond (c)), and probability of failing the CRF test at 4.5 kW/m^2 (Conventional (b) and Double Bond (d)).

The graph on probability of failure for Conventional and Double Bond installation was repeated in Figure 7.12 with a revised specification limit of 2.2 kW/m^2. The left graph shows that this underlay now fails the test with a probability of much less than 0.1% for weights above 1110 g/m^2. By the "a fortiori" argument, the probability of failure at this specification limit would be even less for Double Bond installation (see the right graph).

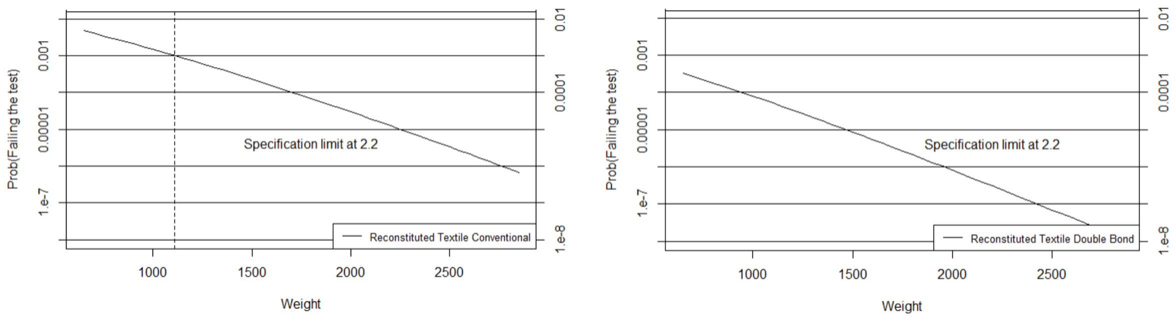

Figure 7.12: Probability of failing the CRF test at 2.2 kW/m^2; Reconstitude Textile; with Conventional (left graph) and Double Bond (right graph).

Summary: For Reconstituted Textile underlay, samples have a probability of less than 0.1% of failing the test with the specification limit at 2.2 kW/m^2 for weights above 1110 g/m^2 for Conventional installation and above 650 g/m^2 (the minimum sample weight) for Double Bond. With the specification limit raised to 4.5 kW/m^2, the probability of failing the test for Double Bond installation is less than 0.1% weights greater than 1800 g/m^2. For Conventional installation, the weights have to be above 2610 g/m^2 to have the failing probability less than 0.1%.

Felt Underlay with Conventional

There are 18 samples for Felt and all have Conventional installation method. The graphes of CRF against Weight (Figure 7.13) show that the probabilities of failing below 0.1% for the 4.5 kW/m^2 limit only for weights above 2710 g/m^2 (see the left graph), where for the 2.2 limit, the weights are greater than 1200 g/m^2 (see the right graph).

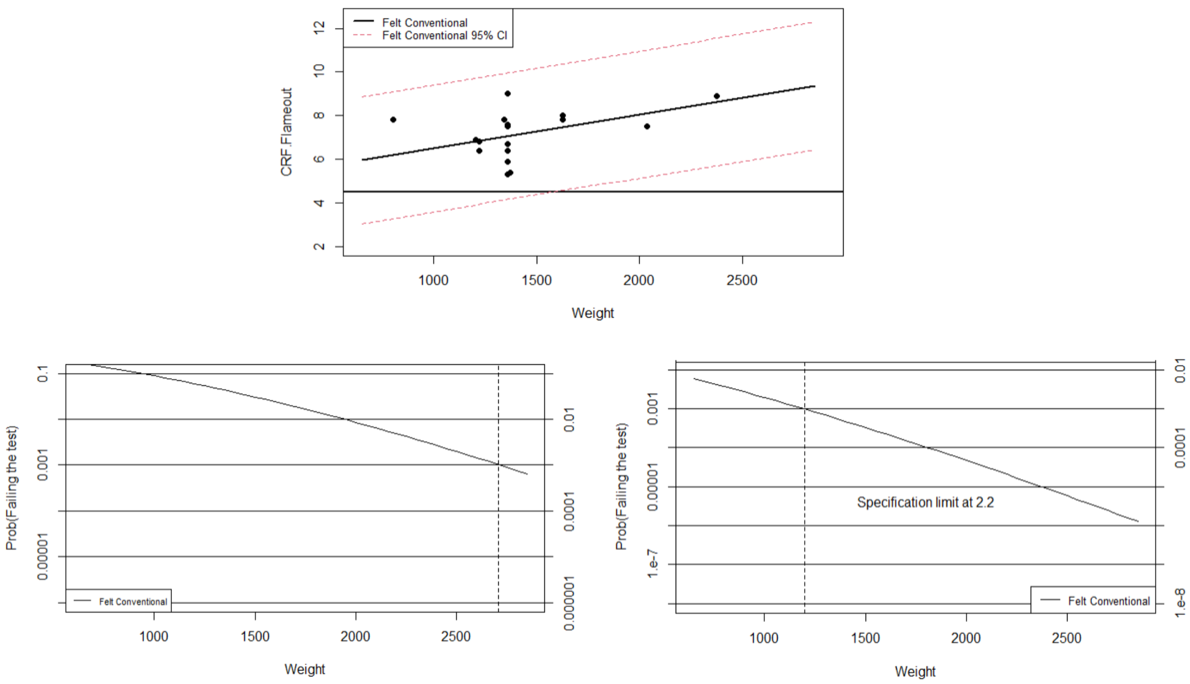

Figure 7.13: CRF vs Weight for Felt (top graph) and implied probability of failing the CRF test at 4.5 kW/m^2 (left graph) and 2.2 kW/m^2 (right graph).

Summary: For Felt underlay with Conventional installation, it meets the requirements for the specification limit of 2.2 kW/m^2 when the weights are above 1200 g/m^2, but fails to achieve the required performance against the specification limit of 4.5 kW/m^2 for weights below 2710 g/m^2.

Crumb Rubber underlay with Double Bond

There are only 6 samples of Crumb Rubber all with Double Bond installation. It appears only having 5 samples in Figure 7.14 because the second triangle (CRF = 7.4) is actually two points with slightly different weights (1017 and 1020 g/m^2). Also because their weight range is very small of these six samples, the estimated 95% confidence intervals are very large (red dotted lines on the top graph). The probabilities of failing below 0.1% for the 4.5 kW/m^2 limit only for weights above 2430 g/m^2 (see the left graph), while for the 2.2 kW/m^2 limit, the probabilities of failure is below 0.1% for weights above 920 g/m^2 (the right graph).

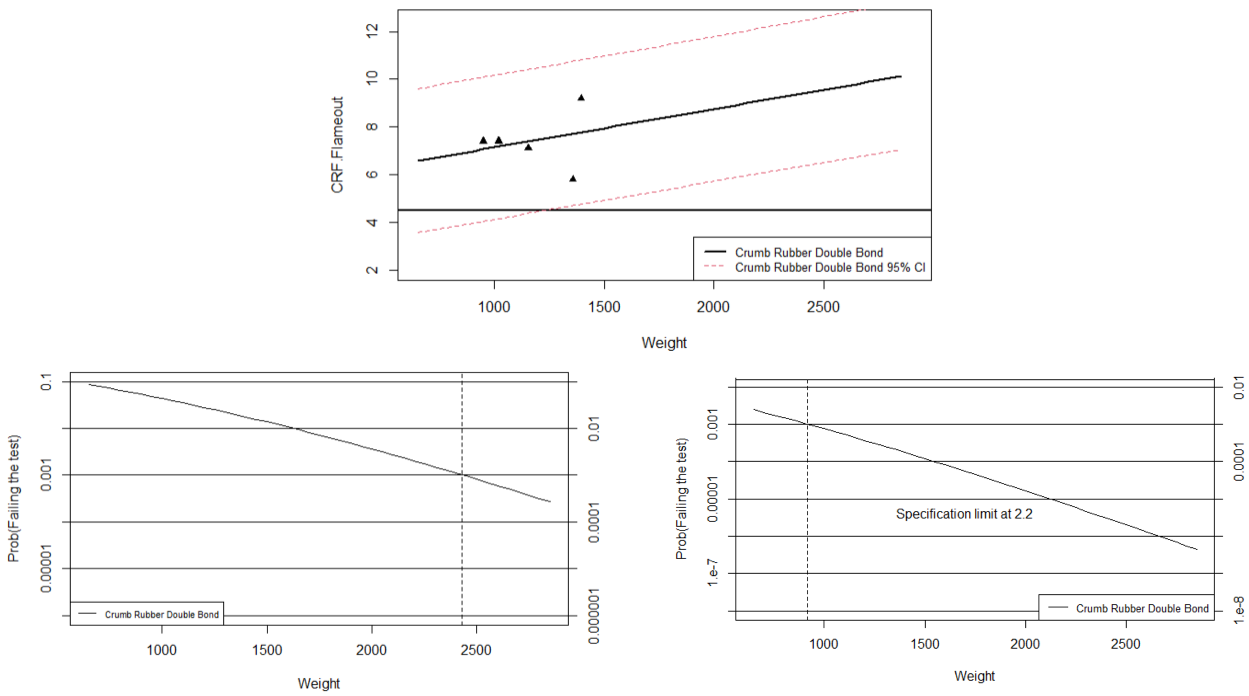

Figure 7.14: CRF vs Weight for Crumb Rubber (top graph) and implied probability of failing the CRF test at 4.5 kW/m^2 (left graph) and 2.2 kW/m^2 (right graph).

Summary: For Crumb Rubber underlay with Double Bond installation, it meets the requirements for the specification limit of 2.2 kW/m2 when the weights are above 920 g/m2, but fails to achieve the required performance against the specification limit of 4.5 kW/m2 for weights below 2430 g/m2.

7.2 Smoke Development Rate (SDR)

7.2.1 DETERMINING THE EFFECTS OF THE COVARIATES

An analysis of the 405 values of SDR was conducted with all the covariates included. We note that in this analysis, the log (base e) of SDR is used. The analysis shows that there are significant effects related to Underlay and Weight, but Pile, Manufacturing Method, Installation Method, and %Wool do not contribute to the regression. An initial assessment of the effects suggests the following:

- Installation Method should be dropped from the model since it adds nothing.
- Nil underlay has strong negative effects (t=–12.5, P<0.0001) relative to Rebond Foam (baseline), while all other underlays are not statistically different from Rebond Foam.
- The linear effect of Weight is evident (t=–6.37, P<0.0001).
- The standard deviation of the residuals was calculated for each of the categories. They were not significantly different, generally being between 0.50 to 0.65 and reaching a high of 0.93 for Rubber.

Outliers

There are three outliers with their SDR = 4. The Normal probability plot which follows shows two values with a residual of about –3 and –2.8, highly unusual.

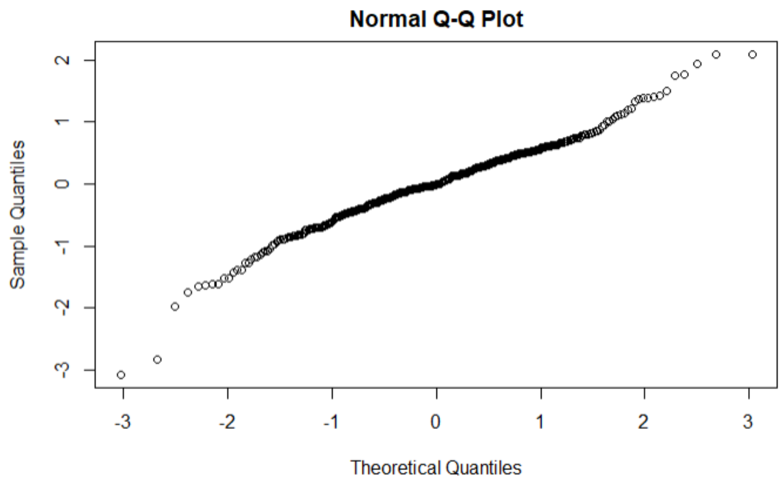

Figure 7.15: Normal probability plot for 397 residuals from analysis of log SDR values.

The following table (Table 7-2) has shown a group of 17 samples including three outliers (SDR = 4, logged value = 1.386) from two different manufacturers and tested by different labolatories. The first 12 samples (including one with SDR = 4) all have weight 1360 g/m^2 and all with Rubber underlay with Conventional installation, from Manufacturer 3, tested by Lab 3. The last 5 samples (including 2 samples of SDR = 4) are all weighted 949 g/m^2 and from Manufacturer 4.

Together they have a standard deviation of 1.319, considerably higher than the standard deviation of 0.856 used overall. This higher degree of variation cannot be explained by the %Wool (all but one are 100% Wool) or the Pile (all are Loop).

Table 7-2 Data to support discussion of outliers

Test.Ref	Manufacturer.ID	Fibre.Details	Pile	Weight	Underlay	Installation	Smoke	log(Smoke)	Test.Lab
56	3	100% Wool	Loop	1360	Rubber	Conventional	54	3.989	3
57	3	100% Wool	Loop	1360	Rubber	Conventional	17	2.833	3
59	3	100% Wool	Loop	1360	Rubber	Conventional	36	3.584	3
60	3	100% Wool	Loop	1360	Rubber	Conventional	102	4.625	3
65	3	100% Wool	Loop	1360	Rubber	Conventional	116	4.754	3
66	3	100% Wool	Loop	1360	Rubber	Conventional	**4**	**1.386**	3
68	3	100% Wool	Loop	1360	Rubber	Conventional	86	4.454	3
72	3	100% Wool	Loop	1360	Rubber	Conventional	21	3.045	3
74	3	100% Wool	Loop	1360	Rubber	Conventional	33	3.497	3
76	3	100% Wool	Loop	1360	Rubber	Conventional	227	5.425	3
78	3	100% Wool	Loop	1360	Rubber	Conventional	83	4.419	3
69	3	90% W/10% N	Loop	1360	Rubber	Conventional	119	4.779	3
96	4	100% Wool	Loop	949	Nil	Direct Stick	10	2.303	1
581	4	100% Wool	Loop	949	Rubber	Conventional	139	4.934	2
583	4	100% Wool	Loop	949	Nil	Direct Stick	53	3.970	2
609	4	100% Wool	Loop	949	Nil	Direct Stick	**4**	**1.386**	1
610	4	100% Wool	Loop	949	Rubber	Double Bond	**4**	**1.386**	1

The outliers here are on the low side, whereas we are concerned with estimating the tail of the distribution on the high side.

The resulting prediction equations are shown in the following Table 7-3. It can be seen that the removal of the outliers leaves the equations almost unchanged. However the standard deviation decreases from 0.665 to 0.626.

Table 7-3: Formulae for SDR for major classes, for all piles and installation methods.

Underlays	Full Data	Outlier removed	Remarks
Rebond Foam(102)	4.349–0.552×W	4.346–0.595×W	11 are DoubleBond
Rubber(85)*	4.124–0.552×W	4.193–0.595×W	82 are Conventional
Nil(74)	3.073–0.552×W	3.101–0.595×W	63 are Direct Stick
SBRLatex(61)	4.301–0.552×W	4.305–0.595×W	Only 6 are Conventional
Reconstitued Textile(60)	4.454–0.552×W	4.458–0.595×W	Only 6 are DoubleBond
Felt(17)	4.538–0.552×W	4.538–0.595×W	All Conventional
Crumb Rubber(6)	4.628–0.552×W	4.615–0.595×W	All Double Bond

7.2.2 PRESENTATION OF THE DATA

The standard deviation is now 0.626, estimated on 394 degrees of freedom. Note that the SDR data are plotted on (a) normal scale and in (b) a log scale, so the specification limit is at log(750)=6.62. We plot the data here for the seven classes, and the fitted lines (with common slope). The vertical axis log of the graph = $\log_e$(SDR).

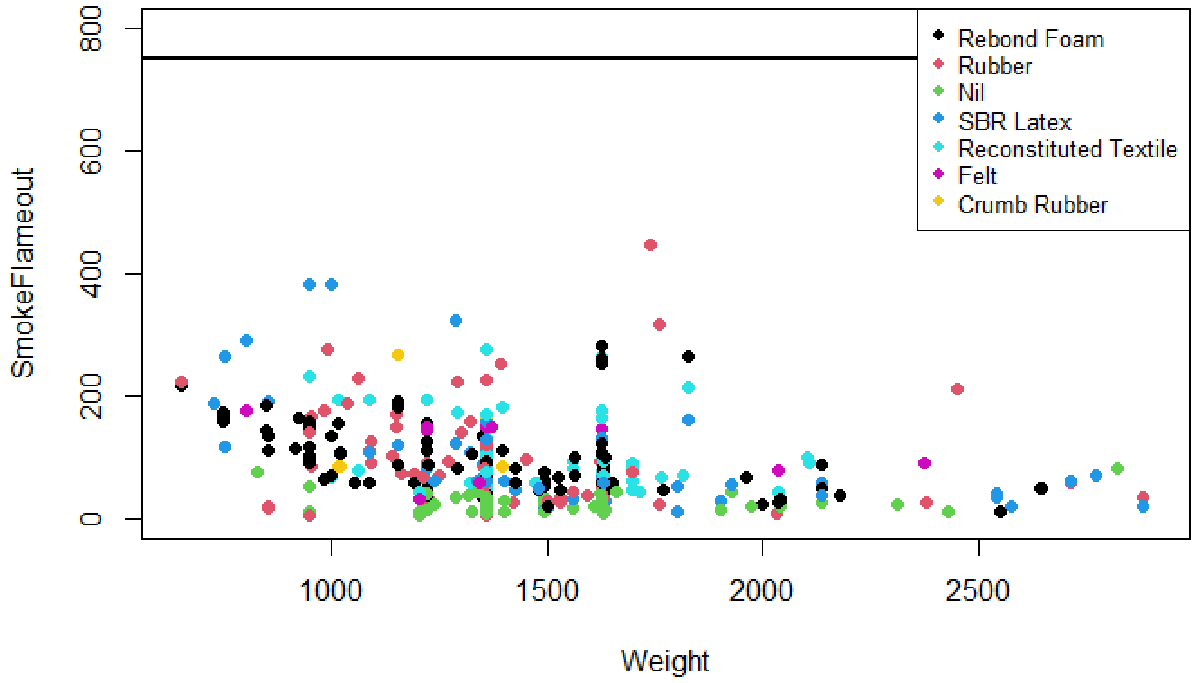

Figure 7.16 (a) Normal scale

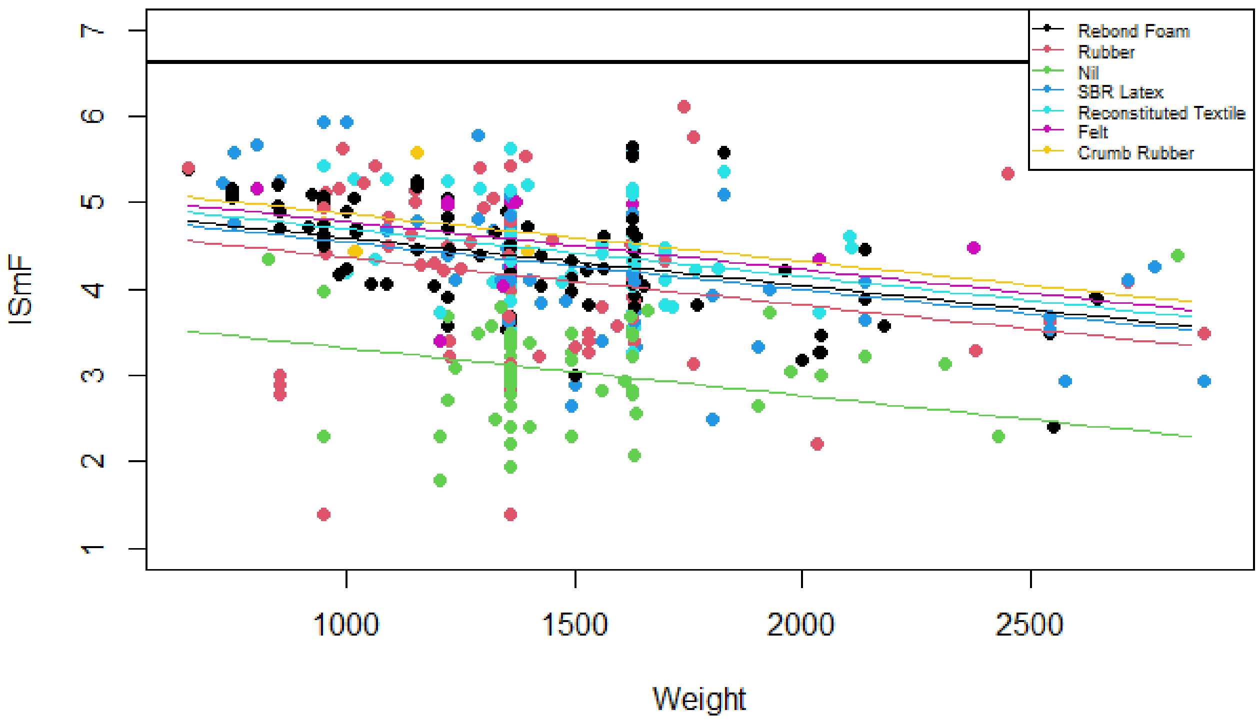

Figure 7.16 (b) Log scale

Figure 7.16: logSDR vs Weight, with fitted lines for major classes.

7.2.3 DETERMINING FAILURE RATES

As we did earlier, we need to determine the probability of a sample falling above the specification limit of 750 %.minutes. This corresponds to 6.62 on the log scale. The probability of a sample failing will vary with Weight and also with the type of Underlay.

Rebond Foam, Rubber and Direct Stick Underlay

The graph below (Figure 7.17) shows the fitted lines (solid lines) and the 95% prediction intervals (dashed lines) for the first three underlay classes. This means that there is a 2.5% chance that a future value will lie above the upper dashed line for each of the three Underlay classes.

These 95% two-sided prediction intervals are defined as in the previous section. These can be turned around to give the probability of being below the specification limit of 6.62 by finding the value of α for which

$$(a_i+b_iW) \pm t_{(\alpha, 397)} \sqrt{(s^2+V)} = \log(750)=6.62.$$

When this is solved for α, it provides the (right) tail probability in a t-distribution with 397 degrees of freedom when the t-value is given by

$$\{6.62 - (a_i+b_iW)\} / \sqrt{(s^2+V)}.$$

This provides the curves in Figure 7.18.

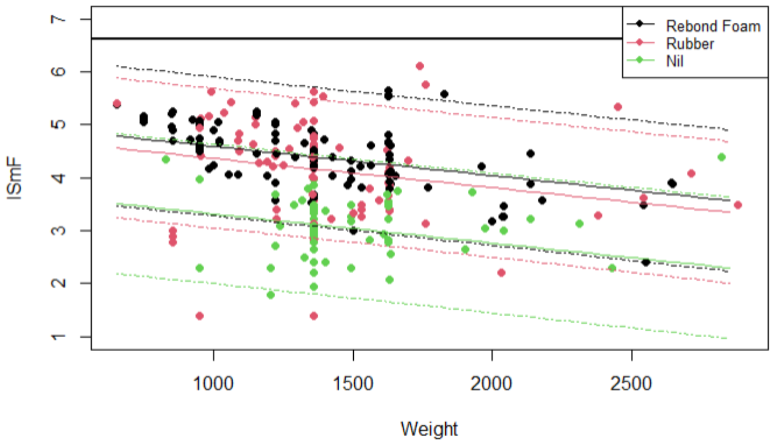

Figure 7.17: logSDR vs Weight, with fitted curves and 95% prediction intervals for first three underlays.

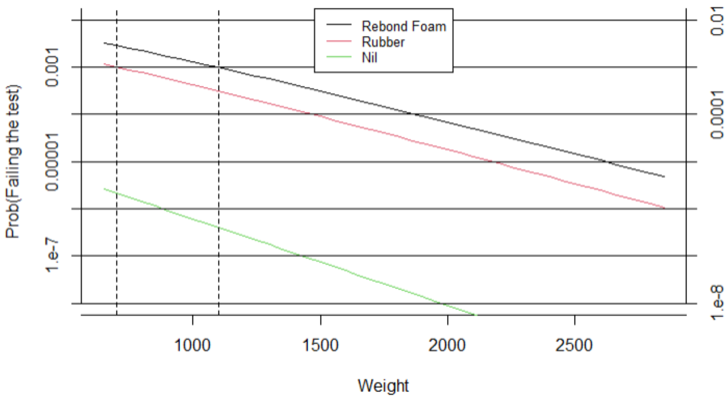

Figure 7.18: Probability of failing the SDR test, for first three classes.

The graphs show that:

- For carpets with Rebomd Foam underlay (——), the probability of failing the test at 1100 g/m^2 is estimated at 0.001, and it is lower than this at all Weights above 1100 g/m^2.
- For carpets with Rubber underlay (——), the probability of failing the test is 0.001 when the Weight is 700 g/m^2 and lower at higher Weights.
- For carpets with no underlay (e.g. Direct Stick)(——), the probability of failing a test is much less than 0. 0001 for all Weights above 650 g/m^2.

SBR Latex, Reconstituted Textile, Felt and Crumb Rubber Underlays

Figure 7.19 shows the data and the fitted lines for the SBR Latex, Reconstituted Textile, Felt and Crumb Rubber underlay.

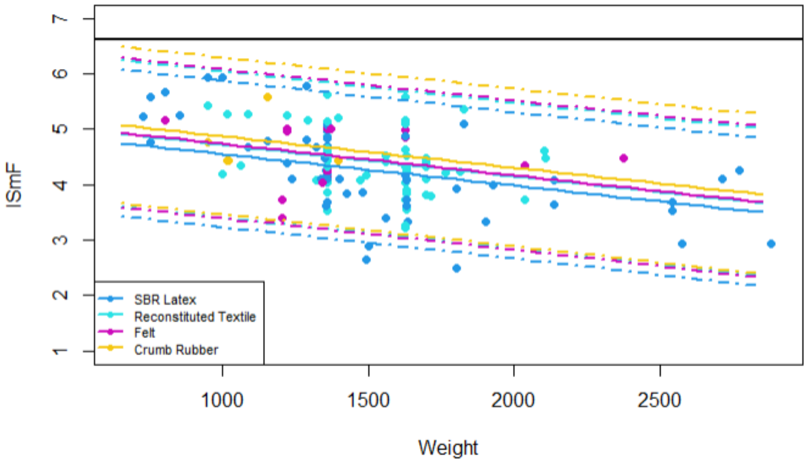

Figure 7.19: logSDR vs Weight, with fitted curves and 95% prediction intervals for another three classes.

Figure 7.20 shows the plot of probability of failure.

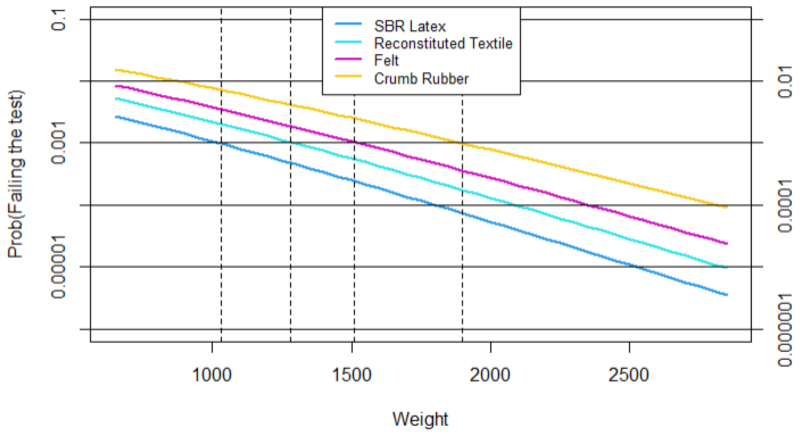

Figure 7.20: Probability of failing the SDR test, for the other three classes.

- For carpets with SBR Latex (——), the probability of failing the test is below 0.001 whenever Weight is greater than 1030g/m^2.
- For carpets with Reconstituted Textile (——), the probability of failing the test is just below 0.001 when the Weight is 1280 g/m^2, and is lower at higher Weights.
- For carpets with Felt (——), the probability of failing the test is estimated to be 0.001 when the Weight is 1510 g/m^2.
- For carpets with Crumb Rubber (——), the probability of failing the test is estimated to be 0.001 when the Weight is 1900 g/m^2.

8 Summary of statistical analysis results

8.1 The Data

- A total of 414 sample test were initially made available, however, only 405 samples were analysed (reasons see below). Within these 405 samples, these were a combination of 319 tests on Wool Only carpets, and another 86 which were Wool/Nylon mix carpets with up to 20% Nylon.

- There were five samples with FR Rubber (FR = Fire Retardant) underlay which were excluded from 2008 CSIRO study with the reasons that FR Rubber should have properties superior to the Rubber class (refer to Page 19 of 2008 CSIRO report).

- A further three samples with SBR Rubber underlaywere also excluded on the grounds that they would provide insufficient data to make any useful statements. A further sample with Synthetic Pad underlay was also excluded with the same reason. This left a total of 405 samples on which the original analysis was based.

- Preliminary analysis had suggested that there was little difference in outcomes relation to the %Nylon and for this reason the original analysis proceeded with all 405 samples in the one data file.

- Following the original analysis, recommendations were made for additional testing to fill some of the gaps in the data.

8.2 Critical radiant flux at extinguishment (CRFFlameout)

- the Critical Heat Flux at extinguishment depends on Underlay and Weight, and there is a significant difference between Conventional, Direct Stick and DoubleBond installation. It appears that there are no significant effects due to ManufMethod (Tufted vs Woven), %Wool (given that all are at least 80% Wool) and Manufacturer. In the earlier report, a common slope was found to provide a suitable description for the way in which *the critical heat flux at extinguishment* depended on Weight of carpet.

- The numbers of samples are sufficient to obtain a reliable estimate of the effects of Installation Method and the effect of Weight. With the additional data, there is sufficient data to estimate the effects of different underlays for most underlays, particularly if it is assumed that there is a common slope of all underlays.

- The distribution of CRFFlameout provides close to Normally distributed residuals in the model. This implies that we can use the tail probability calculations based on the assumption of Normally distributed data.

- For tests with FR Rubber underlay, there are only five samples. No conclusions are drawn.

- For tests with SBR Rubber (three samples) and Synthetic Pad (one sample) underlay, no conclusions are drawn.

Table 8-1 summarises the results for CRFFlameout with varies of underlays and installation methods.

Table 8-1: Summary of results for Total pile mass for Critical Radiant Flux which , for seven classes of underlay.

*

Installation Method	Underlay	TPM (g/m^2)	
		CRF (kW/m^2) 2.2	CRF (kW/m^2) 4.5
Direct Stick	Nil	≥650	≥1290
Conventional	Nil	≥1330	≥2830
	SBR Latex	≥1270	≥2780
	Felt	≥1200	≥2710
	Rubber	≥1000	≥2510
	Reconstituted Textile	≥1110	≥2610
	Rebond Foam	≥1630	NA
Double Bond	SBR Latex	≥650	≥1870
	Reconstituted Textile		≥1800
	Rebond Foam	≥850	≥2340
	Crumb Rubber	≥920	≥2430

8.3 Smoke Development Rate (SDR)

- The distribution of Smoke development rate (SDR) is highly skewed and it is shown that the logarithm (here we use log, base e) of the values provides close to Normally distributed residuals in the model. This implies that we can use the tail probability calculations based on the assumption of Normally distributed data.

- SDR depends on Underlay (including Nil underlay as a class) and Weight, but Pile, Manufacturing

Method, Installation Method, and %Wool do not otherwise contribute to the regression.

- There were no significant differences between the slopes attributable to different types of Underlay. This implies that the regression line of SDR against Weight had constant slope but a different intercept for each of the types of Underlay.

- Differences exist between manufacturers but not significant ($F_{13, 381}$=2.553, P=0.002). In order to provide conclusions which apply generally across manufacturers, manufacturer effects have been left out of the model used.

- Three large outliers was detected – this corresponded to three unusually low SDR value of 4 %.minutes from 12 samples undertaken at a Weight of 1360 g/m^2 and further five samples at Weight 949 g/m^2. These come from only two manufacturers; 12 samples from Manufacturer #3 include a 4 (the outlier) and the remaining 8 values of SDR range from 17–119, while the other five samples (weight 949 g/m^2) from Manufacturer #4 have two 4s (the outlier) and other SDR values from 10–139.

- For carpets with Rebond Foam underlay, the probability of failing the test is 0.001 when the Weight is 1020 g/m^2, and is lower at higher Weights.

- For carpets with Rubber underlay, the probability of failing the test at 820 g/m^2 is estimated at 0.001, and it is lower than this at higher Weights.

- For carpets with no underlay, the probability of failing a test is much less than 0. 0001 for all Weights (sample minumin is 650 g/m^2).

- For carpets with Reconstituted Textile underlay, the probability of failing the test is 0.001 when the Weight is 1330g/m2 and lower at higher Weights.

- For carpets with SBR Latex underlay, the probability of failing the test is below 0.001 whenever Weight is greater than 1030g/m^2.

- For carpets with Felt underlay, the probability of failing the test is estimated to be 0.001 when the Weight is 1400 g/m^2.

- For carpets with Crumb Rubber underlay, the probability of failing the test is estimated to be 0.001 when the Weight is 1850 g/m^2.

- There is insufficient data (only five samples) for FR Rubber to declare a result. Same to SBR Rubber and Synthetic Pad.

Table 8-2: Summary of results for Total pile mass required to meet Smoke development rate (SDR), for seven classes of underlay.

Underlay	Total Pile mass for Smoke Development Rate (SDR) <750 %.min
Rebond Foam	TPM ≥1020 g/m^2
Rubber	TPM ≥820 g/m^2
Nil	TPM ≥650 g/m^2
Reconstituted Textile	TPM ≥1330 g/m^2
SBR Latex	TPM ≥1030 g/m^2
Felt	TPM ≥1400 g/m^2
Crumb Rubber	TPM ≥1850 g/m^2

8.4 Comparison of this 2023 report to the 2007 version

There are several differences between the original 2007 report and this version. In comparison the original report:

- **Data**: There is additional data. An increase of 216 from 198 test reports to 414. Note, some of the 2008 data values have been changed significantly.
- **Underlay**: Inclusion of additional underlay types. Crumb rubber underlay has been added. Reconstituted fibre has been renamed reconstituted textile. Extra combinations of underlay and installation have been added such as Nil with Conventional.
- **Manufacturers**: The first report involved data from 10 manufacturers. This report includes data from 14 manufacturers, one of which is no longer operating. The conclusions apply to 13 manufacturers. Only test data from 14 manufacturers are used in the analysis.

The outcomes of the report has changed:

- **Pile type**: The 2007 analysis showed there was a difference between the cut, loop or cut/loop pile types. Current analysis does not show a statistical difference between the pile types. This has simplified the summary conclusion table.
- **CRF**: The conclusions have changed slightly for all carpet types and underlay combinations.
- **Smoke**: The 2007 analysis showed that all combinations would comply with the smoke development rate t of <750 %.minutes. This is no longer the case.

This is due to the fact that the maximum smoke values in the current test data are more than doubled from 2008 case and reached to about 450 %.minutes, for some underlays.

9 Conclusions

9.1 Overall Summary of Results

A statistical analysis was carried out on a body of wool and wool rich carpets tested according to the fire test AS ISO 9239 Part 1 2003 to assess the likelihood of compliance with the NCC 2022 requirements for floor coverings for Class 2 to 9 buildings (NCC Volume 1, Specification 7). The statistical analysis was performed based on 414 test reports of tests to AS ISO 9239.1:2003 from NATA or ILAC accredited test laboratories. A probability that a carpet of similar construction determined to have a probability of failure of less than 0.1% was considered to provide a level of safety that will satisfy the Performance Requirements C1P4, of the NCC Volume 1 2022.

This report is based upon summary test data collated and supplied to CSIRO by CIAL. The data has been collated from test reports by test laboratories AWTA, APL, WRONZ and BTTG (UK). CSIRO has not received or reviewed the original test reports or certificates and has not provided any of the testing used as input data.

The test reports for wool/nylon blend carpets where the wool content is of 80-100% and the Nylon content is a maximum of 20%, the Total Pile Mass (TPM) is 650g/m^2 or more concluded that all carpets passed both the CRF of 2.2 kW/m^2 and SDR tests regardless of the underlay, construction type, installation technique or manufacturer. Not all meet the CRF criteria of 4.5kW/m^2 and the statistical analysis however concluded that not all carpets have a probability of less than 0.1% of failing the individual tests.

- Table 9-1 summarises whether, with 99.9% confidence, samples of various types of carpets, where the wool content is of 80-100%, can be expected to exceed the minimum value of Critical Radiant Flux (CRF) required by the NCC for floor covering materials. This depends on the underlay, the installation method and the weight (TPM).

- Also shown in the table is an indication of whether, with 99.9% confidence, those samples can be expected to have Smoke Development Rate (SDR) values below the maximum value allowable by the NCC.

- The two points above imply that, for samples of carpets of the types identified, CRF and SDR values should have less than a 0.1% probability of not achieving the predicted performance if tested under AS ISO 9239.1.

No conclusion could be made regarding PVC backed carpet, FR Rubber underlay, SBR Rubber underlay, Synthetic Pad or carpetsmoke tiles. Where a conclusion on the expected CRF or SDR value for a carpet system could not be drawn, or where a tighter specification is required than shown here, the carpet must therefore be formally tested.

Table 9-1: Summary of carpet types and TPM achieving Critical Radiant Flux (top table) and SDR (bottom table) with probability 99.9% and hence which can be considered to conform without further testing. Valid for 100% Wool carpets and Wool/Nylon blend carpets with a wool content not less than 80% wool and with a Total Pile Mass in the range 650g/m^2 to 2882g/m^2

Installation Method	Underlay	TPM (g/m^2)	
		CRF (kW/m^2) 2.2	CRF (kW/m^2) 4.5
Direct Stick	Nil	≥650	≥1290
Conventional	Nil	≥1330	≥2830
	SBR Latex	≥1270	≥2780
	Felt	≥1200	≥2710
	Rubber	≥1000	≥2510
	Reconstituted Textile	≥1110	≥2610
	Rebond Foam	≥1630	NA
Double Bond	SBR Latex	≥650	≥1870
	Reconstituted Textile		≥1800
	Rebond Foam	≥850	≥2340
	Crumb Rubber	≥920	≥2430

Underlay	Smoke Development Rate (SDR) 750 %.min
Rebond Foam	TPM ≥1020 g/m^2
Rubber	TPM ≥820 g/m^2
Nil	TPM ≥650 g/m^2
Reconstituted Textile	TPM ≥1330 g/m^2
SBR Latex	TPM ≥1030 g/m^2
Felt	TPM ≥1400 g/m^2
Crumb Rubber	TPM ≥1850 g/m^2

This report is valid for carpet of the above description manufactured Brintons, Feltex Carpets, Godfrey Hirst Australia, Quest Carpets, Tuftmaster Carpets, Victoria Carpets, Cavalier Bremworth, EC Carpets, Prestige Carpets, Above Left, Rugs Carpets and Designs; Signature Floor Coverings, Chaparral Carpet Mills and Supertuft.

CSIRO concludes that is sufficient evidence for a determination of compliance with NCC 2022 Clause C2D11 and Specification 7 fire hazard property requirements for floor linings, limited to the ranges of wool rich carpets and manufacturers specified within Section 5.7 of this report. This conclusion is subject to the limtations stated in this report.

It is understood by CSIRO that determination of compliance with NCC 2022 Volume 1 Specification 7, Clause S7C3 is to be undertaken by the Authority Having Jurisdiction for any specific application.

9.2 Future Testing

Several underlay classes including FR Rubber, SBR Rubber, Synthetic Pad and Tile are excluded in this analysis. To include these compbinations in the analysis, more test reports are needed. In addition, more test reports are desairble in those underlay classes such as Crumb Rubber, SBR Latex (with Conventional installation) and Felt where the current sample size is small.

9.3 Proposed Testing Regime

Ongoing Quality Assurance of any system typically requires some testing even if it is a major reduction in the testing program for QA control, duty of care and risk mitigation. In consideration of these issues CSIRO recommend that CIAL consider providing some level of testing of the carpet / backing combinations. The existing ACCS regime would provide a framework under which the testing can be performed.

9.4 Term of Validity

This assessment report will lapse on 1st May 2028. Should you wish us to re-examine this report with a view to extend the term of validity, apply to us six months before the date of expiry. CSIRO reserves the right at any time to amend or withdraw this assessment in the light of new knowledge.

10 References

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CONTACT US

t 1300 363 400
+61 3 9545 2000
e EnquiriesTeam@csiro.au
w www.csiro.au

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FOR FURTHER INFORMATION

Infrastructure Technologies
Alex Webb
Group Leader Victoria
t +61 3 9545 2584
e alex.webb@csiro.au
w https://research.csiro.au/infratech/

Infrastructure Technologies
Christopher Preston
Director
t +61 3 9545 2557
e christopher.preston@csiro.au
w https://research.csiro.au/infratech/