



# The New Zealand Ecolabelling Trust

## Licence Criteria for Thermal Building Insulants

**EC-25-15**

The New Zealand Ecolabelling Trust  
PO Box 56533  
Dominion Road  
Mt Eden  
Auckland  
New Zealand

Ph: +64 9 845 3330  
Fax: +64 9 845 3331  
Email: [info@enviro-choice.org.nz](mailto:info@enviro-choice.org.nz)  
Website: [www.enviro-choice.org.nz](http://www.enviro-choice.org.nz)

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# Specification change history

Minor clarifications, corrections or technical changes made since the specification was last reviewed and issued in November 2010

Date	Version	Change
June 2012	EC-25-12 June	A discrepancy in the classification of Borax between HSNO and the Risk Phrases has been investigated and based on the available information the specification has been amended to add an exemption for Borax to clause 5.3 b) and an addition of criteria for reviewing and reporting on options to replace borax Clause 5.2.2 f).
04/08/15	EC-25-15 August 2015	Update of Clause 5.6d (cardboard packaging) The requirement has been updated to align with the revised criteria in EC-10-14 Packaging and Paperboard Products and is consistent with cardboard packaging requirements across all relevant ECNZ specifications.

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# 1 Introduction

Environmental Choice New Zealand (ECNZ) is an environmental labelling programme which has been created to help businesses and consumers find products and services that ease the burden on the environment. The programme results from a New Zealand Government initiative and has been established to improve the quality of the environment by minimising the adverse and maximising the beneficial environmental impacts generated by the production, distribution, use and disposal of products, and the delivery of services. The programme is managed by the New Zealand Ecolabelling Trust (the Trust).

ECNZ operates to the ISO 14024 standard "Environmental labels and declarations - Guiding principles" and the Trust is a member of the Global Ecolabelling Network (GEN) an international network of national programmes also operating to the ISO 14024 standard.

ISO 14024 requires environmental labelling specifications to include criteria that are objective, attainable and verifiable. It requires that interested parties have an opportunity to participate and have their comments considered. It also requires that environmental criteria be set, based on an evaluation of the environmental impacts during the actual product or service life cycle, to differentiate product and services on the basis of preferable environmental performance.

The life cycle approach is used to identify and understand environmental issues (adverse or beneficial impacts) across the whole life of a product or service (within a defined product or service category). This information is evaluated to identify the most significant issues and from those to identify the issues on which it is possible to differentiate environmentally preferable products or services from others available in the New Zealand market. Criteria are then set on these significant and differentiating issues. These must be set in a form and at a level that does differentiate environmentally preferable products or services, is attainable by potential ECNZ licence applicants and is able to be measured and verified. As a result of this approach, criteria may not be included in an ECNZ specification on all aspects of the life cycle of a product or service. If stages of a product or service life cycle are found not to differentiate environmentally preferable products or services, or to have insufficient data available to allow objective benchmarking in New Zealand, those stages will not generally be included in criteria in the specification. For some issues, however, (such as energy and waste) criteria may be set to require monitoring and reporting. These criteria are designed to generate information for future reviews of specifications.

The New Zealand Ecolabelling Trust Board is pleased to publish this proposed revised specification for Thermal (resistive-type) Building Insulants. The specification has been published to take account of substances harmful to the environment, energy management and consumption of resources.

This proposed revised specification sets out the requirements that Thermal (resistive-type) Building Insulant products will be required to meet in order to be licensed to use the Environmental Choice New Zealand Label. The requirements include environmental criteria and product characteristics. The specification also defines the testing and other means to be used to demonstrate and verify conformance with the environmental criteria and product characteristics.

This proposed revised specification has been prepared based on an overview level life cycle assessment, information from specifications for similar products from other GEN-member labelling programmes, relevant information from other ECNZ specifications, information made available from product suppliers and advice from independent environmental scientists.

Once finalised, this specification will be valid for a period of five years. Twelve months before the expiry date (or at an earlier date if required), the Trust will initiate a further review process for the specification.

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## 2 Background

As a building product, thermal insulants are unusual. For most building products, the majority of the overall life cycle environmental impacts occur at the manufacturing stage. However, for thermal insulants a significant environmental impact in their life cycle occurs during their use in the building, having the potential to reduce the energy consumption required for space heating and space cooling over the lifetime of the building.

Achieving good in-situ thermal performance is therefore critical to the overall environmental impact of the insulant. There are several key aspects that determine the overall environmental impact over the life cycle of the insulant including representative and informative product labelling; correct handling of the product; and correct installation. As an example, the thermal performance of an insulant can be reduced by 50 % even if small (5 %) gaps remain after installation.

Energy management requirements have been included in this specification to encourage energy efficiency during manufacture and reduce overall energy use. For similar reasons, waste management requirements are also included.

Insulation products used in New Zealand are generally manufactured from sheep's wool, glass wool or polyester. Cellulose (paper), mineral wool (rock or slag) polystyrene and foams (e.g. polyisocyanurate or polyurethane) may also be used. Each of these insulation types has potentially significant environmental impacts associated with its manufacture.

Sheep's wool insulation is derived from a renewable resource, however, chemicals and grease-laden effluent from the scouring process may adversely impact receiving waters if the correct process controls are not in place. Sheep's wool insulation is often treated with borate to resist pests, fire and mold<sup>1</sup>. Borate is mined from natural deposits and is a non-renewable resource. Sheep's wool insulation may be blended with some polyester fibre to reduce slumping in wall cavities<sup>2</sup>.

Glass wool insulation often includes the use of a high percentage of recycled glass cullet, although some virgin sand is required. Phenol formaldehyde binders are commonly used and formaldehyde emissions can be produced during manufacture<sup>3</sup>. Boron may be used as a flame retardant and treatment against microbial growth<sup>3</sup>.

Mineral wools are derived from non-renewable sources such as virgin rock, however, iron ore blast furnace slag can also be used. This is a waste product from the iron making process. Phenol formaldehyde is commonly used to bind the fibres and, as for glass wool, formaldehyde emissions can be produced during manufacture<sup>2</sup>.

Cellulose insulation is most commonly derived from recycled newsprint and waste telephone directories<sup>4</sup>. It is typically composed of 80 % paper and 20 % fire retardants, insect resist agents and acrylic binders<sup>3</sup>. Borates are commonly used as flame retardants and insect resist agents, and can be leached from the paper if it gets wet<sup>3</sup>. The additives in cellulose insulation may make it difficult to recycle at end-of-life<sup>2</sup>.

Polymer-based materials (polyester, polystyrene, polyisocyanurate and polyurethane) are made from fossil fuel feedstock. However, high proportions of recycled materials are often included in polymer-based insulation products, and some of these products are easily recycled at end-of-life, e.g. polyester and polystyrene.

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<sup>1</sup> [http://www.energysavers.gov/your\\_home/insulation\\_airsealing/index.cfm/mytopic=11560](http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11560)

<sup>2</sup> <http://www.smarterhomes.org.nz/materials/insulation-materials>

<sup>3</sup> <http://www.aerias.org/DesktopDefault.aspx?tabindex=2&tabid=78>

<sup>4</sup> <http://www.cellulose.org/CIMA/TableEnvironmentalFactsMaterialsTable.php>

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Polystyrene, polyisocyanurate and polyurethane are all available as sprayed foam or foam board. Polyisocyanurate is a foam made from isocyanurate and polyol and is similar to polyurethane<sup>1</sup>. It is mostly used for heating and air condition ducts, as well as for roofing insulation and walls of warehouses, factories and office buildings. Polystyrene insulation comes in two forms – expanded polystyrene (EPS) and extruded polystyrene (XPS). Due to concerns about the depletion of the ozone layer, chlorofluorocarbon (CFC) blowing agents in polymer foams were replaced by hydrochlorofluorocarbon (HCFCs) which have significantly lower ozone depletion potential (ODP) than CFCs, but they do have very high global warming potential (GWP)<sup>5</sup>. There are currently two major replacement options for HCFCs in foam manufacturing: hydrofluorocarbons (HFCs), a group of fluorinated greenhouse gases with zero ODP, but which still have high GWP, and natural blowing agents such as CO<sub>2</sub> and hydrocarbons which have both low ODP and GWP<sup>5</sup> (see Section 3 for definitions of ODP and GWP).

The potential impacts of different types of insulation materials can be reduced by promoting the use of recycled raw materials. Restricting the use of certain hazardous substances (e.g. formaldehyde binders and bleaching of cellulose) can further reduce potentially harmful manufacturing impacts.

The benefits of having well insulated buildings include improved indoor comfort levels, a reduction in respiratory problems<sup>6</sup>, warmer internal surfaces, a reduction in the reliance on fossil fuels for heating, which contribute to global warming, an improved durability of internal finishes and a reduced risk of mildew growth.

Based on a review of currently available information, the following product category requirements will produce environmental benefits by improving energy efficiency, reducing the use of non-renewable fuel stocks and hazardous substances and reducing global warming contributions. As information and technology change, product category requirements will be reviewed, updated and possibly amended.

### 3 Interpretation

**AS/NZS** means Australian/New Zealand Standard.

**ASTM** means American Society for Testing and Materials.

**Blowing agent** means a substance (gas, liquid) that is able to produce cells in the plastic structure of a foam. This process can vary according to the property of the substance, e.g. a liquid may develop cells when changing into gas and a gas may expand when pressure is released<sup>5</sup>.

**Cellulose fibre** insulation means fibrous insulation manufactured from macerated paper or paperboard stock and modified with chemical additives.

**CFC** means chlorofluorocarbon.

**EPS** means expanded polystyrene.

**GEN** means Global Ecolabelling Network.

**Global Warming Potential (GWP)** is a measure of how much a gas is estimated to contribute to global warming. It is a relative scale that compares the contribution of the gas to that of the same mass of carbon dioxide (CO<sub>2</sub>), which has a GWP of 1, over a defined time frame. E.g. methane has a

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<sup>5</sup> Published by the German Technical Cooperation – Programme Proklima and commissioned by the German Federal Ministry for Economic Cooperation and Development

<sup>6</sup>[http://www.asthmafoundation.org.nz/healthy\\_homes.php](http://www.asthmafoundation.org.nz/healthy_homes.php)

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**GWP of 21 (100-year time frame).** This means that, over 100 years, methane will be approximately 21 times more heat-absorptive than CO<sub>2</sub> per unit of weight.

**HCFC** means hydrochlorofluorocarbon.

**HFC** means hydrofluorocarbon.

**ISO** means International Organisation for Standardisation.

**Label** means the Environmental Choice New Zealand Label.

**Loose fill insulants or loose fill insulation** means insulants, which are made from macerated paper, mineral fibre, sheep's wool and polyester.

**Ozone Depleting Potential (ODP)** is a relative value that indicates the potential of a substance to destroy ozone gas (and thereby damage the Earth's ozone layer) as compared with the impact of a similar mass of chlorofluorocarbon-11 (CFC-11). CFC-11 is assigned a reference value of 1. E.g. a substance with an ODP of 2 is twice as harmful to the ozone layer as CFC-11.

**R-value** means thermal resistance, measured in m<sup>2</sup>oC/W or m<sup>2</sup>K/W.

**Recycled Content/Recycled Materials** includes:

- **Post-Consumer:** Material generated by households, or by commercial, industrial and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.
- **Pre-Consumer:** Material diverted from the waste stream during a manufacturing process. Excluded is re-utilisation of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.

**Resistive-type thermal insulant** means any of the following bulk insulation types:

- a board-type thermal insulation materials,
- b loose-fill and spray on thermal insulation materials, and
- c segment and blanket-type thermal insulation materials.

**Thermal insulant or thermal insulation** means bulk (resistive-type) thermal insulant.

**XPS** means extruded polystyrene.

## 4 Category definition

This category includes all bulk, resistive-type insulation products where at least 95 % by weight of the insulation material is comprised of one or more of the following materials: glass wool, mineral wool, polyester, wool, cellulose, EPS, XPS, polyisocyanurate or polyurethane.

It excludes reflective foil-type insulants and those used for specialist applications, such as pipe and hot water cylinder lagging.

To be licensed to use the Label, a thermal (resistive-type) building insulant must meet all of the environmental criteria set out in clause 5 and product characteristics set out in clause 6.

## 5 Environmental criteria

### 5.1 Legal requirements

#### Criteria

- a The product must comply with the provisions of all relevant environmental laws and regulations that are applicable during the product's life cycle.
- b Materials or processes involved in the production of an insulation product may not be under the direct control of a licence applicant/holder. Where this is the case, the licence applicant/holder must have and implement a formal supplier regulatory compliance management/assurance programme that:
  - includes documented requirements for suppliers to provide raw materials or services compliant with applicable environmental regulatory requirements (for example in supply contract conditions);
  - identifies suppliers, materials or processes that involve, or would be expected to be subject to a high level of regulatory control and/or which present a high potential risk of regulatory non-compliance;
  - includes appropriate requirements (based on the risk assessment) for suppliers to provide assurance to the licence applicant/holder on the supplier's environmental regulatory compliance.

#### Verification required

Conformance with this requirement shall be demonstrated by providing a written statement on regulatory compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be supported by documentation identifying the applicable regulatory requirements and demonstrating how compliance is monitored and maintained. In cases where there is a high potential risk associated with environmental regulatory compliance and limited assurance provided by the licence applicant/holder's supplier regulatory compliance management programme, the Trust's assessor may require an on-site inspection at the relevant supplier's premises.

#### Explanatory notes

Relevant laws and regulations could, for example, include those that relate to:

- producing, sourcing, transporting, handling and storing raw materials and components for manufacture
- manufacturing processes
- handling, transporting and disposing of waste products arising from manufacturing
- transporting product within and between countries
- using and disposing of the product.

The documentation required may include, as appropriate:

- procedures for approving and monitoring suppliers and supplies
- information provided to customers and contractors regarding regulatory requirements.

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Assurance and/or information that licence applicants/holders may require from their suppliers could include:

- evidence of a formal certified environmental management system (for example an ISO 14001 certificate) and supporting records on regulatory compliance (for example, copies of regulatory requirements registers, procedures to manage regulatory compliance, monitoring and evaluation reports on regulatory compliance, internal or external audits covering regulatory compliance and management review records covering regulatory compliance);
- copies of published environmental, sustainability and/or annual reports expressly addressing environmental regulatory compliance (for example verified Environmental Statements prepared under the European EMAS regulations);
- audit reports completed by independent and competent auditors addressing regulatory compliance (for example, reports for other eco-label licences or reports from regulator audits);
- participation by the supplier in the licence applicants/holders own supplier audit programme.
- It is not intended to require licence holders to accept increased legal responsibility or liability for actions that are outside their control. The Trust's intention is to ensure any potential for environmental regulatory non-compliance associated with an ECNZ labelled product is managed to a level that minimises risk of reputation damage to the ECNZ label and programme.

## **5.2 Raw materials**

### **5.2.1 Threshold for material-specific criteria**

Any insulant material in the insulation product shall meet the requirements for the relevant raw materials set in Clauses 5.2.2 through 5.2.6 if it contributes more than 5 % of the weight of the product.

### **5.2.2 Glass wool (fibre glass) and mineral wool**

#### **Criteria**

- a The product must meet the following minimum recycled content requirements, when calculated on a 12-month rolling basis and measured by weight of the final product:
  - 45 % for glass, or
  - 40 % for mineral, rock or slag
- b Licence holders must:
  - i maintain records of the types and percentages of recycled content used in licensed products;
  - ii have and implement an ongoing programme to review options and increase recycled content in licensed products until an optimal level is achieved, as determined by the required performance characteristics of the product or availability of recycled materials; and
  - iii report annually to ECNZ on the progress of the programme.
- c Non-recycled sand and rock for use as raw materials in glass and mineral wools must come from mining operations with documented mine remediation programmes.
- d The applicant/licensee must have a procurement programme which ensures that virgin raw materials do not come from environments that are protected for biological and/or social reasons.

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- e Licence holders must have and implement an ongoing programme to review options to replace formaldehyde-containing binders in licensed products and report annually to ENCZ on the progress of the programme.
- f Licence holders must have and implement an ongoing programme to review options to replace Borax (boron) in licensed products and report annually to ENCZ on the progress of the programme.

### **Verification required**

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. The statement shall be supported by documentation as follows:

- documentation including records from the previous 12-month period to demonstrate that the recycled content limits are being met;
- information about the recycled content review programme, including performance testing, if relevant and an annual report as required by b) iii);
- certificates or other evidence of a documented mine remediation programme;
- information about the virgin fibre procurement programme and records of the supplier, nature and geographical source of all raw material inputs;
- description of the raw material procurement management systems in place to ensure that the requirement in a) and b) are consistently met;
- material safety data sheets (MSDS/SDS) for all binders used; and
- annual report to ENCZ on replacement of formaldehyde-containing binders and procurement of recycled content.

### **5.2.3 Polyester/polyethylene terephthalate (PET)**

#### **Criteria**

- a The product must meet contain a minimum of 20 % recycled content, when calculated on a 12-month rolling basis and measured by weight of the final product.
- b Licence holders must:
  - i maintain records of the types and percentages of recycled content used in licensed products;
  - ii have and implement an ongoing programme to review options and increase recycled content in licensed products until an optimal level is achieved, as determined by the required performance characteristics of the product or availability of recycled materials; and
  - iii report annually to ECNZ on the progress of the programme
- c The amount of antimony in the virgin polyester fibres shall not exceed 260 ppm.
- d Licence holders must research and report annually on the feasibility of obtaining data on VOCs emitted during polymerisation and fibre production of virgin polyester.

If emissions data is obtained from virgin fibre manufacturers this should be submitted to ENCZ. Emissions should be reported as g VOCs /kg of produced polyester resin and should include the test method used. (VOCs are any organic compound having, at 293.15 K a vapour pressure of 0.01 kPa or having a corresponding volatility under the particular conditions of use.)

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## Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. The statement shall be supported by:

- documentation including records from the previous 12-month period to demonstrate that the recycled content limits are being met;
- information about the recycled content review programme, including performance testing, if relevant and an annual report as required by b) iii);
- either a declaration of non-use of antimony, production information showing the amount of antimony in the virgin polyester, or a test report using the following test method: direct determination by Atomic Adsorption (AA) Spectrometry. The test shall be carried out on the raw fibre;
- Annual report on VOC emissions from virgin fibre production.

### 5.2.4 Wool

#### Criteria

- a Virgin wool fibre destined for an ECNZ licensed insulation product must meet the requirements set for scoured wool in EC-31 Textiles, Skins and Leather or EC-04 Wool and Wool-rich Carpets.  
OR
- b 100 % of the wool used in the insulation product must be recycled material.

## Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be supported by documentation as follows.

For a:

- a copy of the ECNZ certificate covering the scoured wool; OR
- an assessment report showing compliance with the requirements of EC-31 or EC-04, completed by an independent assessor from the ECNZ register and appointed by ECNZ; AND
- production and quality control processes and records to demonstrate that the insulation product includes scoured wool meeting the applicable requirements in EC-31 or EC-04.

For b:

- documentation, including records from the previous 12-month period to demonstrate that the recycled content limit is being met.

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## 5.2.5 Cellulose

### Criteria

- a The product must contain 100 % recycled content with a minimum of 80 % post-consumer recycled content, when calculated on a 12-month rolling basis and measured by weight of the final product.
- b Cellulose fibre must not be bleached for reuse. It is accepted that the fibre may have been bleached during its previous lifecycle.

### Verification required

Conformance with this requirement shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. The statement shall be supported by documentation including records from the previous 12-month period to demonstrate that the recycled content limits are being met.

## 5.2.6 EPS, XPS, polyisocyanurate and polyurethane

### Criteria

- a The product must meet the following minimum recycled content requirements, when calculated on a 12-month rolling basis and measured by weight of the final product:
  - 30 % for Expanded Polystyrene (EPS) or Extruded Polystyrene (XPS),
  - 15 % for polyisocyanurate
  - 5 % for polyurethane
- b Licence holders must:
  - i maintain records of the types and percentages of recycled content used in licensed products;
  - ii have and implement an ongoing programme to review options and increase recycled content in licensed products until an optimal level is achieved, as determined by the required performance characteristics of the product or availability of recycled materials; and
  - iii report annually to ECNZ on the progress of the programme.
- c Insulants shall not be manufactured using blowing agents with a global warming potential (GWP) of more than 140, measured over a 100 year time frame.
- d Blowing agents must have an ozone depleting potential (ODP) of zero.

### Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. The statement shall be supported by:

- documentation including records from the previous 12-month period to demonstrate that the recycled content limits are being met;
- information about the recycled content review programme, including performance testing, if relevant and an annual report as required by b) iii);
- identifying the blowing agents used and their ODPs and GWPs.

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GWP and ODP of common blowing agents are given in Appendix A. For determining the ODP and GWP of substances not included in Appendix A, reference should be made to one of the following:

- Daniel, J.S., and G.J.M. Velders (Lead Authors), A.R. Douglass, P.M.D. Forster, D.A. Hauglustaine, I.S.A. Isaksen, L.J.M. Kuijpers, A. McCulloch, and T.J. Wallington, Halocarbon scenarios, ozone depletion potentials, and global warming potentials, Chapter 8 in Scientific Assessment of Ozone Depletion: 2006, Global Ozone Research and Monitoring Project— Report No. 50, 572 pp., World Meteorological Organization, Geneva, Switzerland, 2007. [http://www.wmo.ch/pages/prog/arep/gaw/ozone\\_2006/ozone\\_asst\\_report.html](http://www.wmo.ch/pages/prog/arep/gaw/ozone_2006/ozone_asst_report.html)
- US EPA Ozone Depleting Substances website <http://www.epa.gov/ozone/science/ods/index.html>
- Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. <http://ipcc-wg1.ucar.edu/wg1/wg1-report.html>

If alternative reference sources are used, ECNZ will require full details of the reference source or a copy of the document, if it is not readily and freely available.

### 5.3 Hazardous substances

Trace levels (<0.1 % by weight) of substances reported in MSDS to be potentially present as contaminants and impurities in raw materials or additives are exempt from Clause 5.3

#### Criteria

- a The following substances shall not be added to the insulation product or used during the production process:
  - Polybrominated diphenyl ether flame retardants;
  - Brominated paraffin flame retardants;
  - Short-chained chlorinated paraffin flame retardants;
  - Tin, lead, mercury, cadmium or chromium-containing catalysts or additives.
- b Substances which are classified as carcinogenic, mutagenic or toxic to reproduction shall not be added to the insulation product.
  - Insect resist treatments are excluded from this criterion as they are specifically addressed in c) below.
  - Formaldehyde is exempt from this criterion as it is specifically addressed in Clauses 5.2.2 e) and 5.7.
  - Antimony in polyester is excluded from this criterion as it is specifically addressed in Clause 5.2.3 c).
  - Borax/Boron used in glass wool insulation is exempt from this clause as it is specifically addressed in Clause 2.2.2 f).
- c Any insect resist agent used must not be classified as toxic, carcinogenic, mutagenic or toxic to reproduction.

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## Verification required

Conformance with this requirement shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be accompanied by documentation that:

- identifies all the flame retardants, catalysts, additives, insect resist treatments and other hazardous substances used; and
- includes Material Safety Data Sheets (MSDS) for each substance or other information to confirm that the requirements in a)-c) are met.

**NOTE:** Compliance with the requirements in in b) and c) may be demonstrated by providing data indicating that the substance does not have any of the classifications (or combinations thereof) listed in Table 3 (Appendix B).

## 5.4 Waste management

### Criteria

- a The licence applicant/holder and product manufacturer must have effective waste management policies and procedures and/or a waste management programme covering manufacturing operations. These policies should include:
  - use recycled materials in the insulant production, where practicable,
  - recycle waste materials from the production process.
- b Where an insulant product contains recycled materials, the percentage of recycled materials in the product shall be stated on the packaging. This should include the minimum recycled content.
- c Licence holders and product manufacturers must report annually to Environmental Choice New Zealand on waste management, including:
  - quantities and types of waste recovered for reuse internally and externally;
  - quantities and types of waste recycled internally and externally;
  - quantities and types of waste disposed of to landfill;
  - quantities and types of waste burned internally for energy recovery;
  - waste generation related to production; and
  - initiatives taken to reduce waste generation and improve recovery/recycling of waste.

## Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be accompanied by documentation that:

- describes the waste management policies, procedures and programmes;
- supports the stated recycled content;
- includes procedures to ensure the stated level of recycled content is consistently achieved; and
- includes annual reports to Environmental Choice New Zealand on waste generation, minimisation and management.

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## 5.5 Energy management

### Criteria

- a The licence applicant/holder and product manufacturer must have effective energy management policies and procedures and/or an energy management programme.
- b Licence holders and product manufacturers must report annually to Environmental Choice New Zealand on energy management, including:
  - total energy use;
  - breakdown of total energy use to types of energy used;
  - energy use related to production;
  - initiatives taken to reduce energy use and improve energy efficiency; and
  - initiatives taken to calculate and reduce CO<sub>2</sub> emissions associated with energy use.

### Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be accompanied by documentation that:

- describes the energy management policies, procedures and programmes; and
- includes annual reports on energy use and management.

## 5.6 Packaging requirements

### Criteria

- a All plastic packaging must be made of plastics that are able to be recycled in the country where the product is sold.
- b Packaging must not be impregnated, labelled, coated or otherwise treated in a manner, which would prevent or significantly limit recycling (i.e. metallic labels).
- c If PVC packaging is used: Information shall be provided to ECNZ at application and thereafter reported annually on PVC and/or phthalates used in the packaging. This should include information from production records and/or suppliers on:
  - i the percentages by weight of recycled and virgin PVC;
  - ii the particular production processes (membrane cells, non-asbestos diaphragms, modified diaphragms, graphite anodes, mercury cells, closed-lid production etc) used to produce chlorine and VCM for the PVC being used in the packaging for ECNZ-licensed products (including the locations of the production);
  - iii information, where available, on waste disposal, wastewater treatment and emissions to air (occupational exposure, emissions from the factory and emissions from the final PVC resin);
  - iv information on any Environmental Management System (EMS) for the production process, including requirements for waste, water, air and product-related requirements;
  - v the types of stabilisers used;
  - vi the types and amounts of any phthalate plasticisers present in recycled content of the PVC (if that information is available) and/or added when manufacturing PVC;

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- vii research and initiatives implemented on substitutes for phthalates identified as of concern by regulators; and
- viii any product stewardship arrangements for the packaging

**Note:** Regulators have identified the following phthalates to be of concern – dibutyl phthalate (DBP), diisobutyl phthalate (DIBP), butyl benzyl phthalate (BBP), di-n-pentyl phthalate (DnPP), di(2-ethylhexyl) phthalate (DEHP), di-n-octyl phthalate (DnOP), diisononyl phthalate (DINP) and diisodecyl phthalate (DIDP). These phthalates may be prohibited by the Hazardous Substances criteria in clause 5.3.

- d Cardboard packaging shall consist of any combination of:
  - Packaging approved under EC-10  
OR
  - recycled content.  
AND/OR
  - waste wood or virgin fibre from native forests provided the forests are certified under the Forest Stewardship Council (FSC) or the Programme for the Endorsement of Forest Certification (PEFC) as sustainably managed (or equivalent certification)  
AND/OR
  - waste wood or virgin fibre from plantations (including from farm forests or wood lots), provided the plantations are legally harvested.

**NOTE:** Please see Appendix C for details of acceptable certifications for certified sustainable forest management and legally harvested wood.

### Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be supported with the following documentation and evidence.

- Conformance with criteria (a) shall be supported by documentation verifying the packaging is recyclable.
- Conformance with criteria (b) shall be demonstrated by providing samples of all plastic containers and components.
- Conformance with criteria (c) shall be demonstrated by providing initial and ongoing annual reports to ECNZ on PVC and plasticisers used. This should include as much of the available information requested in (c) as possible.
- Conformance with criteria (d) shall be supported by documentation from the packaging manufacturer verifying the recycled content of the cardboard packaging and documentation from the packaging manufacturer verifying the source of all fibre in the cardboard packaging.

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## 5.7 Emissions to indoor air

### Criteria

The following maximum limits for concentrations of VOCs in air (based on the standard room calculation) must not be exceeded by the product when the emission rate is tested in a small scale environmental chamber:

Parameter	Limit
TVOCs C6-C16(Total Volatile Organic Compounds)	≤ 0.5 mg/m <sup>3</sup> (after 7 days)
Formaldehyde	<0.05 ppm (after 7 days)

### Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be supported by an emissions test report and calculations demonstrating the limits are met.

### Testing method

Greenguard GGTM.P066 Standard Method for Measuring and Evaluating Chemical Emissions from Building Materials, Finishes and Furnishings using Dynamic Environmental Chambers”

### Explanatory notes

It is sufficient to test the highest density of each group of products as a worst-case scenario.

## 5.8 Product stewardship

### Criteria

- a The insulation product must not be impregnated, labelled, coated or otherwise treated in a manner which would prevent recycling in New Zealand or in the country where the product is used.
- b Licence holders must report annually to Environmental Choice New Zealand on product stewardship, including:
  - availability, feasibility, and involvement in product take back schemes, including for products which are currently installed;
  - initiatives taken to promote or implement take back schemes;
  - initiatives taken to make products more recyclable; and
  - initiatives or requirements for suppliers or contract manufacturers.

### Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be accompanied by documentation that:

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- includes information which demonstrates that the product can be recycled.
- describes the product stewardship initiatives, procedures and programmes; and
- includes annual reports on product stewardship initiatives.

## 6 Product characteristics

### 6.1 Thermal resistance and testing requirements

#### Criteria

- a All thermal insulant products must have the following minimum thermal resistance:
- Wall products - R 2.5
  - Ceiling products - R 3.4
  - Underfloor products R 1.4

Note: The minimum R-value requirements may be met using one layer or a double-layer system. No more than two layers shall be used to meet the R-value requirements.

- b All thermal insulant products must have a stated thermal resistance which has an appropriate statistical basis, derived from independent laboratory testing. Testing must determine the mean thermal performance of the product, the standard deviation and variations between batches of product.
- c All thermal insulant products must have reports or records demonstrating the product's stated thermal resistance is achieved.
- i Initial test reports must be for independent sampling and testing completed no more than 12 months before the date of application for an ECNZ licence.
- ii A programme for ongoing sampling and testing must be documented and implemented as part of the manufacturers quality management system that:
- covers all licensed products;
  - commences within 6 months of an ECNZ licence being issued;
  - provides for regular sampling and testing for each licensed product manufactured and/or sold during that year;
  - is designed to take into account insulant products where the thermal performance of the insulant is dependent on its storage and re-loft behaviour; and
  - investigates any non-compliances with the stated R-value including those found through random market sampling by independent testing agencies.
- d All thermal insulant products must be reasonably expected to retain 90% of thermal performance for the service life.

#### Verification required

Conformance with these requirements shall be demonstrated by providing a statement of thermal resistance for each product to be licensed. This statement must be supported by:

- reports from independent testing and sampling, completed by a laboratory or testing agency competent to complete the required tests;

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- records of quality checks which demonstrate on-going compliance with the stated R-value of the product;
- documentation from the quality management system on the statistical basis of sampling and relevant production and quality controls;
- results of any random market sampling by independent testing agencies; and
- documentation to support a reasonable expectation of durability as required by (d).

## Test methods

Sampling and testing must be completed using equipment and procedures that meet the requirements of:

- Initial independent test:
  - For low density insulants (e.g. glasswool, wool and polyester): AS/NZS 4859.1:2002 Materials for the thermal insulation of buildings - General criteria and technical provisions.
  - For high density insulants: ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
  - On-going quality monitoring:
  - ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

## 6.2 Informative labelling

### Criteria

- a All thermal insulant products must carry a label meeting the requirements of AS/NZS 4859.1 Materials for the thermal insulation of buildings; Part 1: General criteria and technical provisions. In particular the label must state:
- Manufacturer and manufacturing date (or batch identification)
  - Weight (expressed as either weight per square metre or as bale weight and area)
  - The material the insulant is manufactured from, including, if relevant, the percentage recycled content
  - Maximum storage time or use-by date (if batch identification only is provided), for blanket and segment type only. If insulation products are provided direct to the user from the manufacturer, then written storage instructions must also be provided to the user
  - Thickness
  - R-value and the conditions under which it is achieved (including requirements on temperature or any settling or aging of the material)
  - Time after installation at which product will have re-lofted to its nominal thickness if installed before the use-by date (for blanket and segment type only)
  - Area of insulation before installation
  - Safety instructions.

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- b If two layers are used to meet the R-value requirements in Clause 6.1 a), no indication may be included on the packaging of the individual components to suggest that they comply with the requirements of this specification.
- c If the ECNZ label is used in marketing information for two-layer systems, information must be included to clarify that the label only applies when the two layers are used together and does not apply to individual layers.
- d The thermal insulation material must not require labelling as toxic, corrosive or flammable, in accordance with the New Zealand Hazardous Substances and New Organisms (HSNO) regulations.

### **Verification required**

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be supported by:

- a copy of the label for each insulant product;
- relevant production and quality documentation covering labelling processes; and
- quality control procedures for appropriate labelling of 2-layer systems, if applicable.

## **6.3 Installation instructions (for ALL insulants)**

### **Criteria**

- a Installation instructions must be provided for all insulant products. The installation instructions must:
  - i clearly demonstrate the installation quality level required such as the maximum size of gaps, the allowable extent of folds etc. Clear illustrations identifying both acceptable and non-acceptable practice must be provided;
  - ii state where it is appropriate to use the product and where it is not appropriate to use it (if there is reasonable likelihood of a misunderstanding);
  - iii detail the proper storage, handling and installation requirements so as to minimise any health implications; and
  - iv recommend that the insulation be installed in accordance with NZS 4246:2006 “Energy efficiency - Installing insulation in residential buildings”, where applicable.
- b Details of training requirements for preferred installers and how training and competence is monitored must be provided.

### **Verification required**

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be supported by:

- a copy of the installation instructions for each insulant product: and
- details of training requirements and how training and competence of preferred installers is monitored.

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## Explanatory notes

All thermal insulants must be accompanied by written instructions detailing the proper storage, handling and installation so as to: minimise health implications; achieve the thermal performance stated on the product label; achieve the designed thermal performance for the building component and ensure durability of the insulation material.

### 6.4 Installation instructions (for LOOSE FILL insulants only)

#### Criteria

Suppliers of loose-fill thermal insulants must have an ISO 9001 certified quality management system (or equivalent) that meets the following requirements:

- a it must ensure manufacturing activities meet the requirements of ISO 12574 Thermal Insulation – Loose-fill for horizontal applications in ventilated roof spaces – Part 1: Material.
- b it must cover all insulation installers and require all installers to:
  - i meet the requirements of ISO 12574 Thermal Insulation – Loose-fill for horizontal applications in ventilated roof spaces – Part 2: Installer’s responsibilities;
  - ii have been on an installer training programme;
  - iii have an installation schedule, comprised of a table showing settled R-value versus installation weight and thickness;
  - iv have a calibrated blowing machine to ensure proper density control and maintain calibration records for the blowing machine;
  - v determine the total amount of insulant going in to a building space;
  - vi calculate the installation area, with provision for framing;
  - vii determine, using a documented sampling procedure and suitable equipment (e.g. an ASTM C167 thickness probe), the thickness, weight (per unit area) and therefore the theoretical thermal resistance value of the installed insulant;
  - viii provide a signed installation certificate to the client, showing details iv) through vi) above; and
  - ix keep records (preferably photographic) of all installations.
- c it must include processes to demonstrate, using independent follow-ups of installers, that training and installation procedures are being adhered to and are effective.

#### Verification required

Conformance with these requirements shall be demonstrated by providing a written statement on compliance, signed by the Chief Executive Officer or other authorised representative of the applicant company. This statement shall be supported by:

- relevant production and quality control documentation and records; and
- copies of the installation schedules and installation certificates.

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## **7 Requirements and notes for Licence Holders**

### **Monitoring compliance**

Prior to granting a licence, ECNZ will prepare a plan for monitoring ongoing compliance with these requirements. This plan will reflect the number and type of products covered by the licence and the level of sampling appropriate to provide confidence in ongoing compliance with criteria. This plan will be discussed with the licence applicant and when agreed will be a condition of the licence.

As part of the plan, ECNZ will require access to relevant quality control and production records and the right of access to production facilities. Relevant records may include formal quality management or environmental management system documentation (for example, ISO 9001 or ISO 14001 or similar).

The monitoring plan will require the licence holder to advise ECNZ immediately of any non-compliance with any requirements of this specification which may occur during the term of the licence. If a non-compliance occurs, the licence may be suspended or terminated as stipulated in the Licence Conditions. The licensee may appeal any such suspension.

ECNZ will maintain the confidentiality of identified confidential information provided and accessed during verification and monitoring of licences.

### **Using the Environmental Choice Label**

The Label may appear on the wholesale and retail packaging for the product, provided that the product meets the requirements in this specification and in the Licence Conditions.

Wherever it appears, the Label must be accompanied by the words Thermal Building Insulants and by the Licence Number e.g. 'licence No1234'.

The Label must be reproduced in accordance with the ECNZ programmes keyline art for reproduction of the Label and the Licence Conditions.

Any advertising must conform to the relevant requirements in this specification, in the Licence Conditions and in the keyline art.

Failure to meet these requirements for using the ECNZ and advertising could result in the Licence being withdrawn.

## Appendix A Physical and environmental properties of major blowing agents

Ref: UNEP (2007): 2006 Report of the Flexible and Rigid Foams Technical Options Committee – 2006 Assessment. Nairobi: UNEP/Ozone-Secretariat. Available online: [http://ozone.unep.org/teap/Reports/FTOC/ftoc\\_assessment\\_report06.pdf](http://ozone.unep.org/teap/Reports/FTOC/ftoc_assessment_report06.pdf) [Accessed May 2010]

	CFC-11	CFC-12	HCFC-22	HCFC-142b	HCFC-141b	HFC-134a	HFC-152a	HFC-245fa	HFC-365mfc	HFC-227ea
Chemical Formula	CFC13	CCl2F2	CHClF2	CH3CClF2	CCl2FCH3	CH2FCF3	CHF2CH3	CF3CH2CHF2	CF3CH2CF2CH3	CF3CHFCF3
Molecular Weight	137	121	86	100	117	102	66	134	148	170
Boiling Point (°C)	24	-30	-41	-10	32	-27	-25	15.3	10.2	-16.5
Gas Conductivity (mW/m <sup>2</sup> K at 10 °C)	7.4	10.5	9.9	8.4	8.8	12.4	14.3"	12.5*	10.6*	11.6
Flammable limits in air (vol. %)	none	none	none	6.7-14.9	7.3-16.0	none	3.9-16.9	none	3.8-13.3	none
TVL or OEL (ppm) (USA)	1000	1000	1000	1000	500	1000	1000	n/a	n/a	1000
GWP (100 yr.)**	4000	8500	1700	2000	630	1300	140	820	840	2900
ODP	1.0	1.0	0.055	0.065	0.11	0	0	0	0	0

Table 1: Fluorinated Blowing Agents

	Methylene Chloride	Trans-1,2-dichloroethylene	Isopentane	Cyclopentane	n-pentane	Carbon Dioxide	Isobutane	n-butane	Methyl Formate (Ecomate®)
Chemical Formula	CH2Cl2	C2H2Cl2	CH3CH(CH3)CH2CH3	(CH2)5	CH3(CH2)3CH3	CO2	C4H10	C4H10	CH3(HCOO)
Molecular Weight	84.9	97	72.1	70.1	72.1	44	58.1	58.1	60
Boiling Point (°C)	40	48	28	49.3	36	-139	-11.7	0.5	31.5
Gas Conductivity (mW/m <sup>2</sup> K at 10 °C)	n/a	n/a	13.0	11.0	14.0	14.5	15.9	13.6**	10.7"
Flammable limits in air (vol. %)	none	6.7-18	1.4-7.6	1.4-8.0	1.4-8.0	none	1.8-8.4	1.8-8.5	5.0-23.0
TVL or OEL (ppm) (USA)	35-100	200	1000	600	610	n/a	800	800	100
GWP (100 yr.)**	n/a	<25	<25	<25	<25	1	<25	<25	<25
ODP	0	0	0	0	0	0	0	0	0

Table 2: Non-fluorinated Blowing Agents

- " Measured at 25 °C
- \* Measured at 24 °C
- \*\* IPCC-Report 1996
- \*\*\* Measured at 0 °C

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## Appendix B

### Table 3 – Hazardous substance classifications

European Risk Phrases	New Zealand HSNO Classes	Globally Harmonised System
<b>Carcinogens, Mutagens and Reproductive Toxins</b>		
R40 limited evidence of a carcinogenic effect	6.7B	Carc. 2, H351
R45 may cause cancer	6.7A	Carc. 1A and 1B, H350
R46 may cause heritable genetic damage	6.6A	Muta. 1B, H340
R49 may cause cancer by inhalation	6.7A	Carc. 1A and 1B, H350
R60 may impair fertility	6.8A	Repr. 1A and 1B, H360
R61 may cause harm to the unborn child	6.8A	Repr. 1A and 1B, H360
R62 possible risk of impaired fertility	6.8B	Repr 2, H361
R63 possible risk of harm to the unborn child	6.8B	Repr 2, H361d
R68 possible risk of irreversible effects	6.6B	Muta. 2, H341
<b>Toxins</b>		
R23 toxic by inhalation	6.1B or 6.1C	Acute Tox. 2 and 3, H330, H331
R24 toxic in contact with skin	6.1B	Acute Tox. 3, H311
R25 toxic if swallowed	6.1B	Acute Tox. 3, H301
R26 very toxic by inhalation	6.1A	Acute Tox. 2 and 3, H330
R27 very toxic in contact with skin	6.1A	Acute Tox. 1, H310
R28 very toxic if swallowed	6.1A	Acute Tox. 2, H300

NOTE: There are different classification systems for hazardous substances that are used internationally. As the ECNZ specifications need to consider products that are manufactured in New Zealand and overseas, it is necessary to consider the equivalence of hazardous property classification systems in different jurisdictions. The table above shows the (broadly) equivalent European Risk Phrases, New Zealand HSNO Classifications and the United Nations' Globally Harmonised System of Classification and Labelling of Chemicals (GHS) classifications. The EU has implemented the GHS into EU law, replacing the Risk Phrases, and all “substances” (single compounds) have now been transferred to the new classification system. Mixtures must be classified under the GHS by 31 May 2015.

It is important to note that the Risk Phrases, HSNO Classifications and GHS are classification frameworks and the particular classifications applied to a substance may vary between jurisdictions (for example Europe, the United States and New Zealand each have their own agency with responsibility for assessing and classifying hazardous substances). Differences between classifications can be due to the weight placed on particular toxicity studies (i.e. a jurisdiction may consider that a study is flawed) or in the event that new information becomes available (i.e. differences in the timing of the classification or re-classification of a substance). Where there is a discrepancy between the classifications applied to specific substances in the different schemes, The Trust’s appointed technical advisors will review supporting information regarding the classifications on a case-by-case basis to determine and recommend to The Trust how these discrepancies should be managed within the life cycle context of the relevant product category. Where appropriate, technical clarifications and changes, with accompanying explanation, will be included in the relevant specification.

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## Appendix C

# Explanatory notes for types of claims that can be used to demonstrate compliance with the criteria set in 5.6 d).

### Part A:

#### Sustainable Forest Management (SFM):

The FSC and PEFC certification schemes each have a range of certificates/labels. Some of these allow for wood/fibre from certified sustainably managed plantations or forests to be mixed with non-certified wood/fibre. Under FSC Mixed Credit or PEFC Volume Credit methods, wood/fibre or products associated with the certification claim or label may or may not actually contain wood/fibre from the certified sustainably managed source. Certifications accepted by The Trust are those which will ensure that wood from sustainably managed forests, as required in criteria 5.2.1 and 5.2.2, will be actually present in the final ECNZ-licensed product. These are set out below.

**Types of FSC claims** which can be used to demonstrate compliance with the above requirements:

- FSC 100 %
- FSC Mix X % - provided the % meets the requirements
- FSC Mix Credit – only if the manufacturer can demonstrate that actual FSC material is used for the ECNZ products.
- FSC Recycled provided it contains 100% recycled material
- FSC Controlled Wood cannot be used to meet the FSC certified requirements

**Types of PEFC claims** which can be used to demonstrate compliance with the above requirements:

- PEFC Certified – Physical Separation method.
- X % PEFC Certified – Average Percentage method, provided the % meets the requirements
- X % PEFC Certified – Volume Credit method – only if the manufacturer can demonstrate that actual PEFC certified material is used for the ECNZ products.

PEFC Controlled Sources material cannot be used to meet the PEFC certified requirements

**The following certification schemes will be accepted** as equivalent to FSC or PEFC certification of SFM:

- Pengelolaan Hutan Produksi Lestari – Sustainable Production Forest Management certified (PHPL) (<http://liu.dephut.go.id/>).
- Sustainable Forest Management Plans, supported with Annual Logging Plans that have been prepared and approved under the New Zealand Forests Act 1949 (amended in 1993). These Plans must be prepared in accordance with Standards and Guidelines for the Sustainable Management of Indigenous Forests and guidance for preparing Sustainable Management Plans and Annual Logging Plans. Wood sourced from New Zealand indigenous forests covered by approved plans will be accepted as equivalent to FSC sustainably managed forest certification provided compliance with the approved plans is demonstrated through independent on-site assessment.

For any other schemes to be considered, the applicant will be required to provide detailed information that demonstrates the certification scheme is credible and equivalent. For examples of

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the type of information required, refer to the UK Central Point of Expertise on Timber Procurement (CPET) assessments of certification schemes available on [www.CPET.org.uk](http://www.CPET.org.uk).

## **Part B:**

### **Legal harvesting:**

The following certification schemes will be accepted as sources of information to demonstrate legal harvesting, where certificates and chain of custody evidence is available for virgin fibre sources:

- Forest Stewardship Council – “Certified” or “Controlled Wood” ([www.fsc.org](http://www.fsc.org)).
- Programme for the Endorsement of Forest Certification (PEFC) - “Certified” or “Controlled Sources” ([www.pefc.org](http://www.pefc.org)).
- SGS Timber Legality & Traceability Verifications service (TLTV) Verification of Legal Compliance certification (TVTL-VLC) (<http://www.sgs.com/en/Public-Sector/Monitoring-Services/Timber-Traceability-and-Legality.aspx>).
- Rainforest Alliance SmartWood Verification of Legal Compliance (VLC) certification (<http://www.rainforest-alliance.org/forestry/verification/legal>).
- System Verifikasi Legalitas Kayu - Timber Legality Verification System (SVLK) certified, or SVLK/PHPL (Pengelolaan Hutan Produksi Lestari – Sustainable Production Forest Management) certified (<http://liu.dephut.go.id/>).
- Sustainable Forest Management Plans (supported with Annual Logging Plans) that have been prepared and approved under the New Zealand Forests Act 1949 (amended in 1993).

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