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BIO-CIRC Project

European Regional Development Fund

BIO-CIRC Project

Bio(and)**Circular** **I**nsulation for **R**esourceful
Construction

Waste polyester duvets reuse:
Sanitary requirements for incorporation in
insulation products

December 2021



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European Regional Development Fund



backtoearth



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Abstract of the project

The BIO-CIRC Project, Bio(and)Circular Insulation for Resourceful Construction, intends to tackle the building sector's high carbon, energy and resources dependencies while taking advantage of an unused waste resource: polyester from waste bedding.

The project aims to conceive, develop and deploy 3 prototypes of innovative low-carbon thermal insulation material made from polyester and combined with natural fibres. It intends to promote the emergence of a bespoke waste polyester valorisation industry and the use of virtuous Natural and Recycled Fibre Insulation products.

This project is carried out by a cross-channel partnership of 4 key and complementary links in the building sector's value chain:

- Nomadéis (lead partner)
- Alliance for Sustainable Building Products
- Eden Renewable Innovations
- Back to Earth

Planned over 2 years, the BIO-CIRC project receives funding from the European Regional Development Fund (ERDF). The ERDF's contribution amounts to €399,600 for a total budget of €499,500.

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1 Introduction

1.1 Perimeter

The present study of health and safety requirements focuses on the value chain leading to the production of a novel insulation made from waste polyester derived from waste bedding and upholstered items. Indeed, the BIO-CIRC project's aim is to develop new insulation materials made from 100% sanitised and refiberised waste polyester and a mix of reused polyester and natural fibres (wool and hemp chiefly). This study aims to also be a useful guide for insulation manufacturers looking to undertake the same process and obtain clean waste polyester fibres for reuse within an insulation material.

As such, the present study focuses on all the various issues posed by waste handling, sanitising and use within a production line that are relevant to making a product from polyester itself from waste bedding items. This study may however be relevant to a lot of other types of products and value chains as some considerations such workers' health and safety are non-specific.

1.2 Objectives

European and national regulations require all products to be safe in their normal or reasonably foreseeable usage. Products should only be sold if their compliance with product safety regulations has been demonstrated appropriately.

Manufacturers and importers placing products on the Great-British, Northern-Irish and French markets need to demonstrate that they comply with relevant safety requirements that involve:

- Minimising the risks associated with the product
- Generating and keeping records of associated technical documentation
- Placing appropriate labelling on the product
- Providing instructions on how to use it safely

This study first **evaluates general legislative and sanitary frameworks** that may have an impact on sanitising processes and standards followed: the requirements with respect to the end products (insulation made from natural and recycled fibres) and the general requirements with respect to waste handling.

Secondly, this study focuses on the specific challenges posed by bedding items (such as biocontamination) and inspects closer the specific norms surrounding their handling and treatment. In addition, sanitisation methods are reviewed and commented upon for the purpose of producing clean fibres for use in an insulation production line.

Then this study categorises the types of waste arising from various streams (commercial, post-consumer, etc.) and details their main characteristics (availability, risks, costs, etc.) and establishes a decision matrix demonstrating which organisation is most favourable to an insulation manufacturer.



2 Health and safety standards

This section focuses on general health and safety requirements intended to ensure workers' protection (handling waste, manufacturing and installing) and consumer protection (market access requirements, air quality, etc.). Some additional points regarding the link between sanitisation and end-product competitiveness are discussed where appropriate.

2.1 Health and safety requirements for workers

2.1.1 European framework

The legal basis of the EU's protection of workers' health and safety is articles 91, 114, 115, 151, 153 and 352 of the Treaty on the Functioning of the European Union (TFEU)¹. These articles aim to encourage improvement in workers' health and safety and lay down minimal requirements².

The framework directive forms the basis for 25 individual directives in different areas and for Council Regulation (EC) No 2062/94 establishing a European Agency for Safety and Health at Work³. This regulation was repealed and replaced in 2019 by Regulation (EU) 2019/126, establishing the European Agency for Safety and Health at Work (EU-OSHA)⁴. The individual directives include the following:

- Health and safety requirements for the workplace (89/654/EEC) and the provision of **safety** and/or **health signs** at work (92/58/EEC)
- The use of **work equipment** (89/655/EEC amended by Directive 2001/45/EC and Directive 2009/104/EC); of **personal protective equipment** (89/656/EEC) and work with **display screen equipment** (90/270/EEC) and **manual handling** (90/269/EEC)
- **Groups**: pregnant workers (92/85/EEC) and protection of young people at work (94/33/EC)
- **Agents**: exposure to carcinogens (90/394/EEC), and the Directive on protection of workers from the risks related to exposure to carcinogens or mutagens at work (2004/37/EC); chemical agents (98/24/EC amended by Directive 2000/39/EC and Directive 2009/161/EU); biological agents at work (2000/54/EC) and protection against ionising radiation (Directive 2013/59/Euratom repealing previous related directives); protection of workers potentially at risk from explosive atmospheres (99/92/EC); exposure of workers to the risks arising from physical agents (vibration) (2002/44/EC), noise (2003/10/EC), electromagnetic fields (2004/40/EC amended by Directive 2013/35/EU) and artificial optical radiation (2006/25/EC)
- **Substances**: alignment of several directives on classification, labelling and packing of substances and mixtures (Directive 2014/27/EU); Directive 2004/37/EC and following updates deals with workers protection with respect to carcinogens and mutagens which includes the recycling sector
- **Biological agents**: the Biological Agents Directive (2000/54/EC) includes risk posed by biocontaminants and was updated to include SARS-CoV-2 on the list to account for the new risks in the workspace. The Directive encourages employers to assess the risks and take preventive and protective measures to minimise harm, especially for those working in direct contact with biological agents.

In practice, health and safety at work relies on conducting risk assessments, implementing a **risk mitigation strategy** with a health and safety specialist and **documenting the risks**. The website "Your Europe"⁵ presents the EU requirements for health and safety at work. It indicates that the EU rules do not

¹ [Treaty of the functioning of the European Union](#).

² Health and safety at work, [Fact sheets on the EU](#).

³ [Council Regulation \(EC\) No 2062/94](#).

⁴ [Regulation \(EU\) 2019/126](#) of the European Parliament and of the Council of 16 January 2019 establishing the European Agency for Safety and Health at Work (EU-OSHA), and repealing Council Regulation (EC) No 2062/94:

⁵ Your Europe website, [Health and safety at work](#).



specify the method of mitigating risks to employees' health and safety but that national laws may have more precise framework. It advocates following this protocol:

- Collect the relevant **information**;
- Identify the possible **hazards**;
- Assess the **risks** arising from the hazards; for example, estimate the **probability** and **severity** of the consequences and decide whether the risk can be tolerated;
- Plan actions to **eliminate** or **reduce risk**;
- **Document** the risk assessment.

When making a risk assessment you will also need to pay attention to workers who might be especially vulnerable, and to others who might come to your premises such as contractors or visitors.

After identifying the hazards and their possible effects, you will need to **evaluate** and **prioritise** the risks. You should also verify whether there are any **legal** obligations; these may be detailed in the risk assessment specifications or connected to more specific training of workers related to a given risk or activity sector.”⁵

If the employer is not qualified to conduct risk assessments and implement a risk mitigation strategy, they will need to have a health and safety specialist carry it out for them. Free online tools also exist to enable micro and small enterprises to carry out risk assessments⁶.

→ Relevance to the waste duvets sanitisation and transformation

All workers involved along the value chain of the production of an insulation material from waste polyester are protected by the aforementioned EU directives. This includes workers collecting, transporting and handling waste, workers carrying out the manufacturing processes transforming this waste into an insulation material and workers installing the insulation material produced in construction projects. At every step of the project, **risk assessments must be conducted, a risk mitigation strategy must be implemented, and risks must be documented.**

In addition, any manufacturers wishing to produce a natural and recycled fibre insulation product such as the ones developed by the BIO-CIRC project must abide by the European framework and/or their own national legislation.

2.1.2 French framework

There is no specific regulation in France for the collection of waste, but the following norms and regulations should still be considered⁷:

1. **Le Code du Travail**⁸. **Fourth part on health and safety at work, and more specifically:**

- Book I: (L) - Title II. Art.L4121-1 to L 4121-5, on general principles of risk prevention.
 - o Titre III. Chap. I and II, on warning and withdrawal rights.
 - o Titre IV. Art.L4141-1 to L4142- 4, on informing and training workers.
- Book IV: (L) - Title II. Chap. I to VII, on the prevention of biological risks.
- Book II: (R) - Title II. Chap. VIII. Sect.1. Art.R4228-1 to R 4228-15, on sanitary installations.
- Book III: (R) - Title II. Chap. I to III, on the use of work equipment and protection means.

2. **Law n° 84-53 of January 26, 1984 subsequently amended**⁹, on the status of territorial public service workers (*Fonction publique territoriale*)

⁶ Online interactive [risk assessment website](#)

⁷ *Hygiène et sécurité du personnel employé à la collecte des déchets ménagers.*

⁸ Le Code du Travail, <https://code.travail.gouv.fr>

⁹ Loi n° 84-53 du 26 janvier 1984 portant [dispositions statutaires relatives à la fonction publique territoriale.](#)



3. Decree n° 85-603 of June 10, 1985 subsequently amended¹⁰, on hygiene and safety at work as well as preventive medicine in the territorial public service (*Fonction Publique Territoriale*).

4. Various norms:

- EN 840-1 to 840-6, on rolling waste containers.
- NF EN 1501-1 of October 1998 and EN 1501-2, on the general standards and safety standards of waste collection vehicles.
- NF H 96-112-1 to NF H 96-112-4, on the technical characteristics and safety standards of waste container lifting mechanisms.
- NF EN 471 on high-visibility warning clothing.
- X 35-109 (exp.) on the limits on manual charge a person can acceptably carry
- The R 388 recommendation of the CNAMTS (*Caisse Nationale d'Assurance Maladie des Travailleurs Salariés*) on waste collection risk mitigation.

The generic aforementioned health and safety regulations at work also apply to construction workers installing the insulation material. A guidance document on health and safety for insulation materials was produced by the International Labour Organization¹¹.

2.1.3 UK framework

2.1.3.1 General health and safety regulations in the UK

The main health and safety regulations in the UK are listed below:

1. [The Management of Health and Safety at Work Regulations 1999](#)

Main employer duties include:

- Making 'assessments of risk' to the health and safety of its workforce, and to act upon risks they identify, so as to reduce them (Regulation 3).
- Appointing competent persons to oversee workplace health and safety.
- Providing workers with information and training on occupational health and safety.
- Operating a written health and safety policy.

2. [The Workplace \(Health, Safety and Welfare\) Regulations 1992](#)

The main provisions of these Regulations require employers to provide.

- Adequate lighting, heating, ventilation and workspace (and keep them in a clean condition).
- Staff facilities, including toilets, washing facilities and refreshment.
- Safe passageways, i.e. To prevent slipping and tripping hazards.

3. [The Health and Safety \(Display Screen Equipment\) Regulations 1992](#)

Employers are required to:

- Make a risk assessment of workstation use by DSE users, and reduce the risks identified.
- Ensure DSE users take "adequate breaks".
- Provide regular eyesight tests.
- Provide health and safety information.
- Provide adjustable furniture (e.g. Desk, chair, etc.).
- Demonstrate that they have adequate procedures designed to reduce risks associated with dse work, such as repetitive strain injury ([rsi](#)).

¹⁰ [Décret n°85-603 du 10 juin 1985](#) relatif à l'hygiène et à la sécurité du travail ainsi qu'à la médecine professionnelle et préventive dans la fonction publique territoriale.

¹¹ [Safety in the use of synthetic vitreous fibre insulation wools](#) (glass wool, rock wool, slag wool). ILO code of practice.



4. The Personal Protective Equipment at Work Regulations 1992

The main provisions require employers to:

- Ensure that suitable personal protective equipment (PPE) is provided free of charge "wherever there are risks to health and safety that cannot be adequately controlled in other ways." The PPE must be 'suitable' for the risk in question, and include protective face masks and goggles, safety helmets, gloves, air filters, ear defenders, overalls and protective footwear.
- Provide information, training and instruction on the use of this equipment.

5. The Manual Handling Operations Regulations 1992

The main provisions of these Regulations require employers to:

- Avoid (so far as is reasonably practicable) the need for employees to undertake any manual handling activities involving risk of injury.
- Make assessments of manual handling risks, and try to reduce the risk of injury. The assessment should consider the task, the load and the individual's personal characteristics (physical strength, etc.).
- Provide workers with information on the weight of each load.

6. The Provision and Use of Work Equipment Regulations 1998

The main provisions require employers to:

- Ensure the safety and suitability of work equipment for the purpose for which it is provided.
- Properly maintain the equipment, irrespective of how old it is.
- Provide information, instruction and training on the use of equipment.
- Protect employees from dangerous parts of machinery.

7. The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995

Under these Regulations, employers are required to report a wide range of work-related incidents, injuries and diseases to the Health and Safety Executive (HSE), or to the nearest local authority environmental health department. The Regulations require an employer to record in an accident book the date and time of the incident, details of the person(s) affected, the nature of their injury or condition, their occupation, the place where the event occurred and a brief note on what happened. The following injuries or ill health must be reported:

- The death of any person.
- Specified injuries including fractures, amputations, eye injuries, injuries from electric shock, and acute illness requiring removal to hospital or immediate medical attention.
- 'Over-seven-day' injuries, which involve relieving someone of their normal work for more than seven days as a result of injury caused by an accident at work.
- Reportable occupational diseases, including:
 - Cramp of the hand or forearm due to repetitive movement.
 - Carpal tunnel syndrome, involving hand-held vibrating tools.
 - Occupational asthma.
 - Tendonitis or tenosynovitis (types of tendon injury).
 - Hand-arm vibration syndrome (havs), including where the person's work involves regular use of percussive or vibrating tools.
 - Occupational dermatitis.
- Near misses (described in the Regulations as 'dangerous occurrences'). The HSE has produced a list of the kinds of incidents regarded as 'dangerous occurrences'.

8. The Working Time Regulations 1998 (as amended)

These Regulations implement two European Union directives on the organisation of working time and the employment of young workers (under 18 years of age). The Regulations cover the right to annual leave and



to have rest breaks, and they limit the length of the working week which all make a vital contribution to health and safety at work

→ **Relevance to the waste duvets sanitisation and transformation**

From both national frameworks, the intention of the legislator is the same: to protect employee's health and safety. As such, both national frameworks recommend similar action steps regarding identification of risks, mitigating occurrence and impact of identified risks, informing workers and providing adequate safety measures.

As such, any interested industrial should put in place an organisation-wide risk mitigation strategy which may include organisational, collective and individual protective measure as well as respect all the specific labour laws with respect to general health and safety of employees. This task may be initiated via the undertaking of a thorough risk analysis of every stage of the process by an external certified organisation and seek counsel on appropriate remediation actions and strategies.

2.1.4 Specific risks related to installing insulation material

Direct contact and inhalation of dust during the handling, installation, cutting and sawing of insulation materials generate risks for workers. Polyester fibres do not present additional risk factors for workers' health compared to conventional insulants. They may cause **skin** or **eye irritation** due to mechanical action and irritation of airways in case of dust inhalation. Inhalation can lead to several **pulmonary conditions** if particles get attached to the nasal cavity, the lungs or anywhere in between.

In addition, handling contaminated upholstered items' waste prior to sanitisation may cause infections or diseases in workers and as such, specific mitigation strategies may be applied with respect to biocontamination.

Risk mitigation involves **organisational, collective** and **individual protective measures**. Individual protective measures include wearing gloves, goggles, protective equipment with long sleeves and face masks to protect the worker from dust. **Collective protective measures** include reducing dust emissions, helping their evacuation through appropriate ventilation or a suction mechanism and the choice of materials and processes that are least likely to generate dust in the surrounding environment¹².

→ **Relevance to the waste duvets sanitisation and transformation**

Handling waste may require additional biocontamination protective measures which an interested manufacturer must account for. No additional relevant actions have been identified at the sanitisation stage that may increase workers' safety at the installation phase.

¹² [La prévention des risques professionnels des nouveaux matériaux de construction et d'isolation.](#)



2.2 Health and safety requirements for the insulation material

2.2.1 Requirements for buildings in terms of energy performance and relevance to sanitisation process

2.2.1.1 European framework

- **Energy Performance of Buildings Directive (EPBD)**

Publication date	2018 (latest amendments) ¹³
Aim of the directive	Clarify and simplify provisions from previous EPBD
Relevance to insulation manufacturers	This directive enlarged the energy performance requirement to all EU buildings. In addition, it asks for improvements to the energy performance of elements of the building envelope they are retrofitted or replaced, even if it is not within the context of a "major renovation" of the building.
Relevance to production of insulation from waste polyester	This directive shows the EU's interest in buildings' energy performance. Following this directive could create an increase in demand for insulation materials including the waste polyester insulation product. Sanitisation processes should be carried out in a way that maximises the thermal efficiency of the final product, this may be achieved through avoiding alteration to the fibre structure by heat for example.
Link to text	https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF

- **The energy efficiency directive**

Publication date	2012
Aim of the directive	Help the EU reaching the target of 20% energy savings target for the year 2020.
Relevance to insulation manufacturers	Member states are required to refurbish 3% of the surface of their building stock to minimal energy performance requirements (EPBD). Member states must also adopt long-term plans for the renovation of their building stock by 2050 to reduce the overall energy consumption of EU buildings by 80% by that date.
Relevance to production of insulation from waste polyester	The waste polyester product could be used as an innovative alternative to current insulation in the refurbishment of buildings across Europe. In addition, the energy efficiency of the manufacturing processes and specifically the sanitisation process of the insulation product should optimise energy efficiency .
Link to text	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Aco0012

- **The waste framework directive**

Publication date	Implementation is incremental between 2010 and 2020
Aim of the directive	Reduce waste and move towards closed-cycle materials management
Relevance to insulation manufacturers	Binding targets for Member States to reduce waste drastically include the construction and demolition sectors (including insulation). The collection of waste is also regulated.
Relevance to production of insulation from waste polyester	The waste polyester insulation material is in line with waste reduction policies as it aims to recycle bedding waste and transform it into insulation. Sanitisation should be mindful of waste production . For instance, the water and cleaning products used to sanitize the polyester fibres could be used several times to reduce waste.
Link to text	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

¹³ https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_2018.156.01.0075.01.ENG



As part of the European Green Deal¹⁴, the “building and renovating” policy area represents the need for cleaner construction sector. This is particularly relevant to waste polyester, as its aims include incentivising energy-efficient buildings, designing buildings in line with the circular economy, climate-proofing buildings and enforcing rules on the energy performance of buildings. These aims all involve thermal insulation materials and could thus include the product of the BIO-CIRC project.

2.2.1.2 French framework

In France, the legal framework for the thermal insulation of buildings is the Thermal Regulation (*Réglementation thermique, RT*), updated multiple times from 1974 to 2012. In 2020, the RT laws were supplanted by the Environmental Regulation (*Réglementation Environnementale, RE*). All these regulations aim to reduce greenhouse gas emissions by 1/ improving the energy efficiency of buildings 2/ the embodied carbon of building material. This RE effectively, creates a demand for low-carbon insulation materials.

For houses built before 2013, the relevant norm for thermal insulation is the **RT 2007**. The **RT 2018** applies to new constructions and refurbishment works if the surface built or renovated is smaller or equal to 50 m² and extensions to buildings and withing 150 m of the building and don't exceed 30 % of the existing building's surface. This norm requires materials used to have a higher level of thermal performance than the RT 2007 does.

The **RE 2020** notably requires new buildings to produce more energy than they use. While passive houses produce their own energy, the RE 2020 house produces more energy than it needs from renewable sources and can sell the surplus to the grid. A core focus of the RE 2020 is to reduce the greenhouse gas emissions of the building sector in France¹⁵ which will also encompass the grey energy content of the material used in construction. As such, the waste polyester insulation product will have to meet these environmental impact requirements in order to remain competitive.

In addition, the January 2017 law LTECV (*Loi relative à la Transition Énergétique pour la Croissance Verte*)¹⁶ imposes the installation of thermal insulation when carrying out important refurbishment works in residential, office, teaching, commercial or hotel buildings. Decrees n° 2017-919¹⁷ and n°2016-711¹⁸ make the installation of thermal insulation mandatory for:

- A roof refurbishment of at least 50% of the roof surface (except for cleaning and waterproofing)
- Façade restoration on at least 50% of the façade surface (except for a simple cleaning, repair or painting)
- Creation of a new habitable room (except if it is buried or half-buried).

¹⁴ https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

¹⁵ Les [normes à suivre pour l'isolation thermique](#).

¹⁶ [Loi de transition énergétique pour la croissance verte](#).

¹⁷ [Décret n° 2017-919 du 9 mai 2017](#) (applicable au 1er juillet) modifiant les articles R. 131-28-7 et R. 131-28-9 du code de la construction et de l'habitation.

¹⁸ [Décret n° 2016-711 du 30 mai 2016](#) relatif aux travaux d'isolation en cas de travaux de ravalement de façade, de réfection de toiture ou d'aménagement de locaux en vue de les rendre habitables.



→ Relevance to the waste duvets sanitisation

The French legislative framework attaches an increasing amount of importance to thermal insulation in buildings and the overall environmental impact of buildings. These laws and regulations will generate a rise in **construction** and **renovation works involving thermal insulation**. The waste polyester insulation material could enter this market by distinguishing itself from other insulation options. Indeed, if the overall environmental impact of the product is lower than that of other conventional materials, it could become very competitive in this context.

The sanitisation process should be designed to be energy efficient and not to hamper downstream thermal insulation properties and reduce its overall carbon footprint.

2.2.1.3 UK framework

As referenced in the box above, new regulations requiring better thermal efficiency and more insulation, should lead to increased demand for insulation products such as the ones generated during the BIO-CIRC project.

There are a number of voluntary fabric efficiency standards prevalent in the UK such as Passivhaus which are helping to drive demand for insulation. Passivhaus sets the standard for building fabric efficiency and the 15 kWh/m² target for space heating demand is referenced by many other voluntary targets such as LETI and UK Green Building Council.

In terms of regulatory drivers, the new changes to Part L and F of the Building Regulations as part of the new Future Homes and Buildings standard will require all new developments to reach improved levels of thermal efficiency, with new homes in England having to produce around 30% less carbon emissions, and new buildings such as offices and shops will have to cut emissions by 27%.

These regulatory and voluntary drivers should help increase demand for insulation. With the rise in awareness of embodied carbon, more resource efficient and circular models for insulation manufacturing such as those explored during the BIO-CIRC project should be at an advantage.

→ Relevance to the waste duvets sanitisation

Energy efficiency of the sanitisation process should be sought in order to reduce associated carbon emissions and thus enable a product to be competitive on the British market. The sanitisation process should also aim to reduce damage to existing polyester fibre as to preserve their thermal property and thus require less transformation in subsequent processes. In doing so, the product will abide by current standards or best practices.

2.2.2 Requirements for the characteristics of insulation material and relevance to the sanitisation process

2.2.2.1 European framework

- **The eco-design directive**

Publication date	2009
Aim of the directive	Set the conditions for the establishment of implementing measures regulating the environmental characteristics that energy-using and energy-related products need to have in order to be placed in the market.



Relevance to insulation manufacturers	Insulation products are not specifically addressed by this Directive. Nevertheless, the extension of its scope to “other energy related products” opens the possibility of covering “products which do not necessarily use energy but have an impact on energy and can therefore contribute to saving energy”, such as insulation materials.
Relevance to production of insulation from waste polyester	The measures implemented in member states following this directive could impact the requirements in terms of environmental characteristics that the waste polyester product need to meet to be placed in the EU market . The directive outlines two principles which should guide the design of the product but also of the sanitisation process: the energy efficiency should be optimised and the demand on natural resources should be reduced.
Link to text	https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:EN:PDF

• **The Construction Products Directive (CPD)**

Publication date	2013
Aim of the directive	Create a common market for building products by setting quality standards.
Relevance to insulation manufacturers	A building product meeting the standards can attain a CE mark . This mark is a passport to the EU market. The standards now cover fitness for use and 6 essential requirements: <ul style="list-style-type: none"> - Mechanical resistance and stability - Safety in the case of fire - Hygiene, health and the environment - Safety in use - Protection against noise - Energy economy and heat retention When the CPD becomes a CPR (Regulation) sustainability will be the 7th requirement
Relevance to production of insulation from waste polyester	The quality standards presented in the CPD must be met by the waste polyester product for it to access the EU market. Requirements for mechanical resistance and stability are not the main concern for insulation materials, as they do not generally play a part in the structural integrity of a building. Safety is essential and sanitisation can prepare the polyester fibres for treatment to ensure fire safety and safety in use. Energy economy, heat retention and protection against noise are inherently relevant to insulation materials and should be designed for insulation product. <ul style="list-style-type: none"> - A safe hygiene level is guaranteed by sanitising the waste polyester prior to manufacturing the insulation product - The health of workers and users of the product in buildings should be a priority in designing the product and its sanitisation process - The environment should be considered by optimising resource use and waste generation in sanitisation and throughout the production process
Link to text	https://ec.europa.eu/growth/sectors/construction/product-regulation_en

• **The industrial emissions directive (IED)**

Publication date	2010
Aim of the directive	The IED aims to achieve a high level of protection of human health and the environment by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques (BAT). Around 50,000 installations undertaking the industrial activities listed in Annex I of the IED are required to operate in accordance with a permit granted by the authorities in the Member States. This permit should contain conditions set in accordance with the

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	principles and provisions of the IED. The IED is based on several pillars: (1) integrated approach, (2) use of best available techniques, (3) flexibility, (4) inspections and (5) public participation.
Relevance to production of insulation from waste polyester	<p>The IED should be kept in mind when designing the waste polyester product as manufacturing activities including sanitisation must be granted a permit. Pillars (1), (4) and (5) are particularly relevant to the sanitisation process.</p> <p>The integrated approach means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure.</p> <p>The IED requires a site visit to take place at least every 1 to 3 years, using risk-based criteria, in the context of environmental inspections. These visits must be planned for in sanitisation processes.</p> <p>Public participation means that permit applications, permits and the results of the monitoring of releases are available to the public.</p>
Link to text	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0075&cookies=disabled

• **Regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)**

Publication date	2006
Aim of the regulation	Regulates the registration of dangerous chemical substances.
Relevance to insulation manufacturers	<p>Key legislation on chemical substances whether hazardous or not. Insulation manufacturers use chemicals in insulation manufacturing processes. As such, they fall in the ECHA (European Chemicals Agency) "User of chemicals" class¹⁹. As such, they must:</p> <ul style="list-style-type: none"> - Use chemicals safely: comply with the REACH requirements regardless of company size. Operational conditions and risk management measures included in the safety data sheets provided by the supplier must be implemented for each chemical used. - Use biocidal products only for their specified purpose: Biocidal products are hazardous by their nature and can be harmful to humans, animals and the environment. Active substances are only approved for use by specific product types. Specific requirements apply for the labelling and packaging of biocidal products to ensure that they can be used safely.
Relevance to production of insulation from waste polyester	All potential chemicals used in the waste polyester insulation manufacturing or sanitisation must meet the REACH regulation requirements. For sanitisation specifically, this means chemicals used as washing agents must be used according to guidelines specified on labels with appropriate operational conditions and risk management measures.
Link to text	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006R1907

Declaration of Performance

The Declaration of Performance is a key part of the Construction Products Regulation. It provides information on the performance of a product. Each construction product covered by a European harmonised standard or for which a European Technical Assessment has been issued needs this Declaration and has to be CE marked. This helps increase transparency and improves the functioning of the Single Market²⁰. **Manufacturers are responsible** for factory production controls, and for testing and assessing the

¹⁹ ECHA website, [User of Chemicals](#).

²⁰ [Declaration of Performance and CE marking](#).

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construction product's performance. These tasks can also be carried out by an independent party, depending on the risks associated with the product (e.g. fire safety).

CE marking

The **CE marking indicates that a construction product is in conformity with its declared performance** and that it has been assessed according to a harmonised European standard or a European Technical Assessment has been issued for it²⁰. The six following steps must be carried out as part of the CE marking process:

- Identify the applicable directive(s): for insulation products these are likely to be the 305/2011 Construction Products Regulation (CPR) and the 2009/125/EC Ecodesign Directive
- Identify the applicable requirements of the directive(s)
- Identify an appropriate route to conformity: this may involve an authorised third-party assessment depending on the level of risk associated with the product
- Assessment of the product's conformity: the manufacturer usually tests the product and checks its conformity with EU legislation
- Compile the technical documentation
- Make a Declaration and affix the CE Mark: the manufacturer completes a declaration of conformity once they are certain that their product conforms to EU requirements. The CE mark can be affixed by the manufacturer or a designated organisation depending on the level of risk associated with the product.

Directive 2001/95 EC on product safety²¹

The Directive aims at ensuring that products placed on the market are safe. It applies to all the products which are intended for consumers or likely to be used by consumers even if not intended for them, and are supplied or made available, whether for consideration or not, in the course of a commercial activity, and whether new, used or reconditioned. In support of this Directive, the Commission Implementing Decision (EU) 2019/1698 of 9 October 2019 on European standards for products was drafted²². Decision 2010/376/UE was also drafted on July 2, 2010, in support to Directive 2001/95 on the safety requirements European norms must stipulate for products involved in children's sleep²³.

2.2.2.2 French framework

The most important norms and regulations on insulation materials in France are the following²⁴.

ACERMI Certification²⁵

This certification guarantees the long-term performance and reliable production quality of the insulation. It also proves the conformity of the insulation with the building Thermal Regulation of 2012, which enables owners to qualify for government energy renovation benefits. If the ACERMI criteria is met by the product, the manufacturer can affix an ACERMI certification label with the product reference, production date and production factory. The criteria include thermal conductivity, thermal resistance, fire safety, mechanical performance, water resistance, acoustic performance, and dimensional stability. This certification is granted to the company producing the product for two years and is renewable²⁶. The certifying body audits the production line and takes samples of the product to conduct laboratory testing. If the results are satisfactory, the certificate is granted. Then, audits are conducted every semester and in-depth verifications are conducted

²¹ [Directive 2001/95 EC on product safety](#),

²² [Commission Implementing Decision \(EU\) 2019/1698](#).

²³ [Decision 2010/376/UE](#).

²⁴ Unilin Insulation France, [Normes et réglementation](#).

²⁵ ACERMI [website](#).

²⁶ ACERMI [explanation](#).

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every year. ACERMI can decide to suspend the certification if any checks reveal defects, until the defects are corrected by the manufacturer and further checks are conducted²⁷.

Fiches de Déclaration Environnementale et Sanitaire (FDES)²⁸

The FDES forms, equivalent to Environmental Product Declarations, present the results of the life cycle analysis of tested materials in the context of the environmental impact evaluation of buildings they are used in. The FDES details certified quantitative information on the environmental and health impacts of a product such as the emissions of Volatile Organic Compound. **The sanitisation process will have a direct impact on the EPD, notably on such indicators as grey energy and water usage.**

Volatile Pollutant Certification²⁹

Applying the *Décret n° 2011-321* of March 23, 2011 and the *Arrêté* of April 19, 2011 on the labelling of construction products relative to the emissions of volatile pollutants this grade (from A+ to C). Materials that get graded A+ have the weakest level of emissions of volatile organic components and therefore have the best indoor air quality performance. Sanitisation should help in mitigating the emissions of certain pollutants and biocontaminants.

Safety requirements of bedding products

This Decree (*Décret n° 2000-164 du 23 février 2000*) is specifically about the safety requirements of certain bedding products. The requirements are mostly about fire safety and only mention that the bedding items should satisfy the essential requirement of hygiene, without defining it precisely.

In addition, there are two norms that relate to the quality of bedding products:

- NF EN 1162 (1997) on measuring the oxygen index of feathers and duvets. The Oxygen Index determination quantifies the organic materials at the origin of bad odours.
 - o No specifications were found on the oxygen index level for thermal insulation. Limiting the oxygen index limits the flammability of materials
- NF EN 1164 (1998) to determine the turbidity of an aqueous sample of feathers and duvets .

2.2.2.3 UK framework

The Code for Construction Product Information

The Code for Construction Product Information developed by the Construction Product Association's Marketing Integrity Group, sets a level playing field for all construction product manufacturers to ensure that the information they provide passes five tests:

- Clear
- Accurate
- Up-to-date
- Accessible
- Unambiguous

In response to the Grenfell disaster, Dame Judith Hackitt published a report in 2018 – Building A Safer Future. The report confirmed radical change was needed for construction products, particularly in the areas of testing, information and marketing.

²⁷ ACERMI [process explained](#).

²⁸ Inies website, [produits de construction \(FDES\)](#).

²⁹ ADEME website, [Composés organiques volatiles](#).



The Code has been published alongside manufacturer preparation information and Code guidance to drive higher standards in the presentation of construction product information in the manufacturing industry.

Management of the published Code and its verification has been formally handed over from the Construction Products Association to Construction Product Information Ltd.

UKCA Mark

From the 1st January 2023, CE Marking will no longer be accepted on most new products placed on the market in Great Britain and UKCA will be required.

The UKCA (UK Conformity Assessed) marking is a new UK product marking that is used for goods being placed on the market in Great Britain (England, Wales and Scotland). It covers most goods which previously required the CE marking, known as 'new approach' goods.

The technical requirements that must be met and the conformity assessment processes and standards that can be used to demonstrate conformity – are largely the same as they were for the CE marking. The circumstances for self-declaration of conformity for UKCA marking are the same as for CE marking.

Safety requirements of bedding

In the UK the following standards are in place:

- BS 4578 – Test methods for hardness and air permeability for infants' pillows
- BS 6807 – Ignitability of mattresses, upholstered divans, and upholstered bed bases with flaming types of primary and secondary sources of ignition
- BS 7175 – Ignitability of bed covers and pillows by smoldering and flaming ignition sources

→ Relevance to the waste duvets sanitisation

The sanitisation process must not include REACH or toxic substances as well as respect threshold concentration values for certain products (such as fire retardants). In addition, the final product will need to be certified or tested for a wide array of substances in order to be marketable and fulfil the necessary transparency requirements (filling Environmental Product Declaration for example).

It is advised that the manufacturers or organisation that take charge of the waste handling and sanitisation familiarise themselves with the list of prohibited products in the final product and avoid using them throughout the transformation process or respect the threshold values.

In addition, manufacturers should test out multiple sanitisation processes to figure which one impedes the least on such properties as flammability

2.2.3 Optional awards that can boost the waste polyester insulation product competitiveness

2.2.3.1 European framework

- **The eco-label directive**

Publication date	2009
Aim of the directive	The Directive sets out the requirements necessary for a product to obtain the Eco-label . This voluntary scheme - established in 1992 - aims to encourage businesses to raise the environmental performance of their products and

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	services, by offering the 'flower logo' label as the EU sign for excellence in 'green' performance.
Relevance to insulation manufacturers	Insulation manufacturers can aim to obtain the Eco-label to celebrate the high environmental performance of their products and develop their competitiveness.
Relevance to production of insulation from waste polyester	The insulation material from waste polyester could benefit from this label depending on the specific embodied carbon.
Link to text	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Aco0012

2.2.3.2 French framework

Zone Verte Excell

The certification label "Zone Verte Excell" rewards the materials, products and coatings that are compatible with indoor air quality and whose performance exceeds the requirements of applicable regulations. This certification label guarantees that a construction material can be used without risk in indirect contact with wines and certain delicate foods, certifying that the material does not contain targeted contaminants nor toxic solvents in its composition.

As the targeted product, insulation material from waste polyester, is likely to be separated from the users or placed within airtight conditions, this label may not be applicable to the desired market.

2.2.3.3 UK framework

BBA Agrément Certificate

BBA Agrément Certificate is a mark of excellence based on rigorous national and European standards that validate a construction product's specialist formulation, capability and uniqueness.

The BBA is a market-leading UKAS-accredited product certification body [No.0113] to BS EN ISO/IEC 17065:2012, testing laboratory [No.0357] to BS EN ISO/IEC 17025:2017, management systems certification body [No.0113] to BS EN ISO/IEC 17021:2015 and inspection body [No.4345] to BS EN ISO/IEC 17020:2012 within the UK, setting the standard for excellence within the construction industry for products and systems and offering technical expertise and independent 3rd party certification.

NHBC Accepts

NHBC Accepts is a comprehensive review service for innovative products and systems. It is the fast-track route for acceptance of products and systems for use in homes covered by all NHBC warranty and insurance policies, equivalent to around 70-80% of the new homes built in the UK each year. NHBC is the UK's leading independent provider of warranty and insurance for new homes.

An NHBC Accepts logo shows that an innovative product or system has been rigorously assessed and that NHBC considers it can meet their robust NHBC Standards. It also demonstrates that, subject to appropriate design and installation, the system or product can be used in homes covered by NHBC warranty products.

LABC Assured

LABC Assured (previously Registered Details) is a one-off building regulations and standards assessment process for England, Wales and Scotland.

Following the UK Government's announcement on 19th January 2021 that a new regulator was to be established in respect of construction materials within the Office for Product Safety and Standards (OPSS), together with the details emerging from phase 2, module 2 of the Grenfell Tower Public Inquiry, the LABC Board of Directors instigated a comprehensive review of the LABC Assured scheme. This review, conducted in accordance with the general criteria within ISO 10965:2012, has now concluded and its findings reported to the LABC Board, who have resolved that the LABC Assured scheme should be discontinued.

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Cradle to Cradle Certified®

Cradle to Cradle Certified® is the global standard for products that are safe, circular and responsibly made.

Cradle to Cradle Certified assesses the safety, circularity and responsibility of materials and products across five categories of sustainability performance:

- Material Health: ensuring materials are safe for humans and the environment
- Product Circularity: enabling a circular economy through regenerative products and process design
- Clean Air & Climate Protection: protecting clean air, promoting renewable energy, and reducing harmful emissions
- Water & Soil Stewardship: safeguarding clean water and healthy soils
- Social Fairness: respecting human rights and contributing to a fair and equitable society.

There are a number of certified products listed on the C2C directory, including many from companies based in the UK and France - <https://www.c2ccertified.org/products/registry>.

→ Relevance to the waste duvets sanitisation

Manufacturers or organisations in charge of the sanitisation process should consider the whole lifecycle of the product, which includes the sanitisation process, and aim to include air quality, material, and resource circularity (water for the washes for example) circularity, energy efficiency of the process, etc. to boost the end's product environmental performance and increase its marketability.



3 Risks associated with waste bedding items

The bedding feedstock can be considered waste on the basis that it is left over, unwanted or a burden on the producer or holder and it can no longer be used for its original purpose. Waste is generally categorised as hazardous or non-hazardous waste with hazardous waste being further classified in line with waste classification guidance.

3.1 Definition of non-hazardous waste

Non-hazardous waste includes any rubbish or recycling that causes no harm to human or environmental health. Clean, used and condemned filled bedding waste are considered non-hazardous on this basis. Whereas there is a duty of care involved, there are no biocontaminants that would require sanitary treatments of this waste.

3.2 Definition of hazardous waste

There is a risk that a proportion of the waste bedding feedstock could be classed as infectious and as such an examination is required to determine if the waste is classified as hazardous or non-hazardous waste.

According to the UK HSE guidance:

"Waste is considered 'hazardous' under environmental legislation when it contains substances or has properties that might make it harmful to human health or the environment. This does not necessarily mean it is an immediate risk to human health, although some waste can be."

Waste Classification: Guidance on the classification and assessment of waste (1st Edition v1.1.GB) provides guidance on classification of hazardous waste. Appendix C9 of the guidance is relevant to potentially infectious bedding waste. Annex III of the Waste Framework Directive defines HP 9 'Infectious' as:

"waste containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in man or other living organisms."

In establishing whether filled bedding waste is hazardous relies on determining one or more of the following:

- The source person or animal (the patient), is known or suspected to have a disease / infection caused by a micro-organism or its toxin and the waste is likely to contain the viable infectious agent or toxin
- The waste is, or is contaminated with, a culture or an enrichment of a micro-organism or its toxin that may cause disease in man or other living animals
- The waste may cause infection to any person or animal coming into contact with it

There is a risk that a proportion of the filled bedding waste contains one or more biocontaminants such as human and animal urine, faeces, blood, vomit, sputum or any other body fluid or from a person or animal with an infectious condition, food, chemical spillages, mould, fungal and insect infestation.

Such filled bedding should be considered infectious in the absence of data confirming otherwise and be assigned the H9 hazard category and, in turn, any non-infectious filled bedding in contact with potentially infectious bedding should likewise be classed as infectious H9. Infectious materials may contain one or more biological agents.

Biological Agents

The UK Health & Safety Executive maintains a list of Approved Biological Agents that may be relevant to those handling and processing infected waste bedding. The Approved List provides the approved classification of

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biological agents as referred to in COSHH. It is relevant to risk assessment for work with biological agents and the application of appropriate control measures. It is for use by people who deliberately work with biological agents, especially those in research, development, teaching or diagnostic laboratories and industrial processes, or those who work with humans or animals who are (or are suspected to be) infected with such an agent in health and animal care facilities.

Table 2 shows the classifications in the Approved List which assign each biological agent listed to a hazard group according to its level of risk of infection to humans.

Table 2: Classifications in Approved List of Biological Agents

Group 1	Unlikely to cause human disease.
Group 2	Can cause human disease and may be a hazard to employees; it is unlikely to spread to the community and there is usually effective prophylaxis or treatment available.
Group 3	Can cause severe human disease and may be a serious hazard to employees; it may spread to the community, but there is usually effective prophylaxis or treatment available.
Group 4	Causes severe human disease and is a serious hazard to employees; it is likely to spread to the community and there is usually no effective prophylaxis or treatment available.

COSHH requires employees and any other persons working with biological agents in Hazard Groups 2, 3 and 4 to assess the risk of exposure to those biological agents. One of the matters to take into account in such a risk assessment is the approved classification of the relevant biological agents. COSHH specifies four containment levels for activities which involve working with biological agents. Containment levels correspond to the classification of biological agents into Hazard Groups 1 to 4, i.e., Hazard Group 2 biological agents should be handled at Containment Level 2 (see paragraph 3(4) in Part I of Schedule 3 of COSHH). The containment measures required at each containment level are set out in tables in COSHH, Schedule 3, Part II and Part III.

Chemical contamination

Whereas chemical contamination is possible, the most significant hazards arising are biological in nature. All waste arising from the place of use that has not been subject to a cleaning or decontamination process needs to be considered biologically contaminated (infectious) for the purposes of onward processing.

3.3 Contamination risk of bedding items

While research indicated that there is no overarching classification of hazard levels for bedding items, a **classification does exist in healthcare settings where biocontamination is most likely**. Healthcare guidance, standards and regulations provide the most comprehensive means of classifying waste bed linen and mitigating associated risks.

The "Health Technical Memorandum 01-04: Decontamination of linen for health and social care" provides **detailed guidance on classifying, handling and decontaminating linen**. Based on this, table 1 gives 6 classifications for bed linen that help identify the likelihood of biocontamination. The categories are equally applicable to any domestic or commercial setting although the proportions of linen falling into each category will vary depending on the context of their use.



Table 1 – Classification of Bed Linen in healthcare settings

1. Clean Linen	Linen items that are new, have been processed or are otherwise clean and have not yet been used
2. Used Linen	Linen which has been used but is not contaminated with blood or body fluids. Used dry linen from non-infected patients.
3. Condemned Linen	Linen that is no longer functional, fit for purpose i.e., torn or stained
4. Soiled Linen	Used Linen not classified as Fouled Linen or Infected Linen.
5. Fouled Linen	Used Linen that has been fouled by body substances including but not limited to blood and faeces.
6. Known, or Potentially, Infected/Infested Linen	All linen which is grossly contaminated with excreta, blood or body fluids, or contaminated linen from an infectious service user patient who is known, or clinically suspected, to be infectious.

Items 1 to 3 are considered non-infectious whereas items 4 to 6 are considered infectious. Protocols are in place to be able to sort and segregate infectious and non-infectious linen. In line with UK Health Technical Memorandum 01-04, linen not sorted and segregated at the local level is considered infectious. Therefore items 1-3 would be considered infectious if they were not segregated from items 4-6.

Domestic use is not a controlled setting so any waste arising from domestic settings would need to be sorted in accordance with relevant guidelines. If this was not conducted, all filled bedding waste would be considered infectious. Further hazard classification follows in the next section of the review.

→ Relevance to the waste duvets sanitisation and transformation

Most waste bedding items represent a risk for handlers and workers and, as such, maximum care should be taken to respect national and European frameworks where applicable.



4 Sanitisation processes and risk management

4.1 Pre-processing waste handling

Handling non-sanitised bedding waste exposes workers to **biological risks**. In addition, typical risks waste handling workers are exposed to are relevant. This includes accidents with **vehicles**, accidents with **equipment falling** onto employees, **slips, trips, falls** and **manual handling injuries**.

Most managers will be familiar with the risk assessment process, which includes the following steps:

1. Identify the hazards
2. Decide who might be harmed and how
3. Evaluate the risks
4. Decide on control measures
5. Record significant findings and implement controls
6. Review the assessment and update if necessary.

In order to mitigate these risks, personal protective equipment (PPE) should be worn at all times by workers in contact with the waste. In addition, all equipment should be well maintained, and processes should be devised to reduce the probability of incidents occurring. Once safety protocols are created, employees should be trained to respect them and enforce them³⁰.

4.2 Sanitisation processes

If a chosen waste stream involves non-sanitised waste bedding, two options should be considered:

1. Transporting the waste to a professional laundry facility for sanitisation
2. Sanitizing the waste as part of the regular operations of the insulation manufacturing

If the use of professional laundry services is the preferred options, it might incur higher costs to the insulation manufacturer but might also guarantee that the waste has been cleaned to professional standards and is therefore safe to use within the context of manufacturing insulation material. It may also be worth investigating the environmental impact of the processes used by professional laundries as it may drive the final product's footprint up and therefore degrade its competitiveness in this regard.

Alternatively, the manufacturer may decide to include the sanitisation as part of their normal operation. The following sections detailing the sanitisation methods may therefore be of interest.

Different **levels of sanitisation** exist, depending on the application the clean bedding is intended for. It can be sterile for use in hospitals, have a controlled microbiological quality as an intermediate or simply be clean. For use as insulation material clean should be sufficient as a sanitisation level.

4.2.1 Washing and laundering

Recommendations to ensure cleaning and disinfection of used (soiled and foul) linen are:

- A 65°C temperature hold for a minimum of 10 minutes within the wash cycle; or
- A 71°C for not less than 3 minutes;
- Mixing time must be allowed to ensure heat penetration and assured disinfection. A sluice cycle must be added into the cycle when dealing with foul linen

³⁰ Safety in waste handling and collection, <https://app.croneri.co.uk/feature-articles/safety-waste-handling-and-collection>



Or for temperatures <65°C

- Addition of hypochlorite may be possible, but efficacy may be reduced by the presence of soiling, detergents and alkalis in the main wash;
- Disinfection with hypochlorite is only reliable if the linen can tolerate its addition and if sodium hypochlorite is added during the penultimate rinse of the cycle;
- A final concentration of 150 ppm available chlorine must be achieved for a minimum of 5 minutes exposure time;
- Detergents with biocidal activity.

Detergents with a biocidal action may include disinfectants, sanitisers, anti-microbials, anti-bacterials, etc. Detergents that contain biocidal active substances must comply with the Biocidal Products Regulation - Regulation (EU) No 528/2012 (as amended) - in addition to complying with the Detergents Regulation. Detergents which contain surfactants which also have active biocidal activity and that are used as disinfectants are exempt from the following provisions in the Detergents Regulation:

- Primary and ultimate degradability testing
- Preparation of a risk assessment and the requirement to use test and analytical methods in the detergent legislation (providing the substance with biocidal activity is as stated in the retained [Biocidal Products Regulation](#))

The bedding waste items should be dried by pressing and centrifugal spin-drying. It is crucial to ensure **perfect drying is achieved to avoid mildew formation.**

While pre-consumer bedding items are generally whitened using bleach, oxygenated water or peracetic acid and oxygenated water mix, it does not seem useful to whiten the waste bedding to create a thermal insulation material.

Washing and laundering appears to be the best choice to sanitise waste bedding for reuse into an insulation production line.

4.2.2 Dry heat treatment

Dry heat treatments offer another method of sterilisation which is effective provided that the steriliser has an automatic controller that will ensure that appropriate temperatures are achieved throughout the load. Temperatures must be maintained for the duration of the sterilising time and required conditions are as follows:

- 160 to 170° C for 120 minutes;
- 170 to 180° C for 60 minutes;
- 180 to 190° C for 30 minutes.

As well as the strict controls required for this method, dry heat sterilisation time is long and additional time is required for the items to cool to room temperature prior to use. Items must be able to withstand at least 160°C for long periods. Given the heat lability of polyester fibres, **prolonged exposure to temperatures in excess of 160°C is likely to alter the physical structure of the polyester fibres.** PET is a semi-crystalline polymer with a melting point of approximately 255°C (range from 250 to 260°C) and a glass transition temperature of approximately 70°C (range from 65 to 76°C³¹). Above the glass transition temperature, PET fibres soften. However, the material maintains good physical properties up to 175°C. Dry heat treatment is likely to alter the physical properties of the polyester fibres due to exposure to excessive temperatures for prolonged period. In addition, the time required for the core of bulk material to reach and hold the required temperature and allowing for cool down renders this process impractical. Finally, the high heat expended

³¹ Polymer Database, [Poly\(ethylene terephthalate\)](#).



during the process might drive the end-product to have a higher grey energy and thus a higher environmental impact.

It may also be possible to expose the insulation to a lower heat during production providing the resulting insulation has a very low water activity once packed and providing the packaging is sufficiently moisture resistant to ensure the water activity of the insulation does not increase to unacceptable levels prior to installation. Water activity is the relative humidity generated by a material in a closed container at equilibrium. A value below 0.5 is sufficient to prevent any microbial growth and greatly reduces the survival rate of microbes.

4.2.3 Moist heat treatment

Steam sterilization is conducted in an autoclave with materials exposed to direct steam contact at the required temperature and pressure for the specified time. Four factors influence the effectiveness of the process: steam, pressure, temperature, and time.

The dryness fraction of steam should ideally be $\geq 97\%$. High steam temperatures are obtained under pressure. A minimum of 121°C is required to achieve effective steam-sterilisation. **A minimum exposure period of 30 minutes is required at 121°C to kill microorganisms.**

The autoclave is a sealed pressure vessel. A pre-vacuum is pulled to evacuate all the air from within the chamber and from within the porous material to be sterilised. When all air is evacuated from the vessel, steam is fed into it and maintained under set pressure and temperature for sufficient time to allow all material to reach target temperature for the prescribed period.

With respect to physical alteration of the PET fibres, **it is unlikely that waste bedding exposed to temperatures of 121°C will alter the physical properties of PET fibres for use in an insulation material.**

Moist heat destroys microorganisms by the irreversible coagulation and denaturation of enzymes and structural proteins. However, **the process does not remove contaminants from contaminated materials** and does not eliminate the possibility of contaminants to act as viable food sources.

Whereas moist heat sterilisation is a viable means of sanitising waste bedding materials, it does not provide a permanent method of decontaminating material. **It is therefore not a viable option for contaminated materials.** However, the technology could be employed to treat non-contaminated waste bedding.

→ Relevance to the waste duvets sanitisation and transformation

BIO-CIRC partners recommend considering washing and laundering as the primary option to decontaminate the waste bedding items as they are the less likely to denature the PET fibres. It is recommended to test out various mixing times, temperatures cycles and cleaning products to find which method yields consistent results (removal of particles and biocontaminants) while being energy and cost efficient.

As this method is rather water intensive, it may be considered to use a water recycling process in order to render the process more environmentally friendly.

4.3 Appropriate risk management per class of bedding waste

An assessment of the hazard classification was made using current UK waste classification guidance and a classification of the material based on HTM 01 04. Table 3 outlines the hazards, mitigation and appropriate decontamination/disinfection technology for each category of filled bedding waste.

Table 3 – Risks and mitigation measures to follow according to the type of waste bedding encountered



Item	Description	Infectious	Waste Classification	Mitigation actions	Decontamination & Disinfection
1. Clean Filled Bedding	Filled bedding items that are new, have been processed or are otherwise clean and have not yet been used	No	Non-Hazardous	Segregate from 4-6	None
2. Used Filled Bedding	Filled bedding which has been used but is not contaminated with blood or body fluids. Used dry linen from non-infected patients.	No	Non-Hazardous	Segregate from 4-6	None
3. Condemned Filled Bedding	Filled bedding that is no longer functional, fit for purpose i.e., torn or stained	No	Non-Hazardous	Segregate from 4-6	None
4. Soiled Filled Bedding	Used filled bedding not classified as Fouled Linen or Infected Linen.	Yes	Hazardous – Infectious H9	Disinfect and decontaminate	Wash, launder
5. Fouled Filled Bedding	Used filled bedding that has been fouled by body substances including but not limited to blood and faeces.	Yes	Hazardous – Infectious H9	Disinfect and decontaminate	Wash, launder
6. Known, or Potentially, Infected/Infested Filled Bedding	All filled bedding which is grossly contaminated with excreta, blood or body fluids, or contaminated linen from an infectious service user patient who is known, or clinically suspected, to be infectious.	Yes	Hazardous – Infectious H9	Disinfect and decontaminate	Wash, launder
7. Mixed Filled bedding waste 1-3	Mixed waste comprising clean, used or condemned filled bedding.	No	Non-Hazardous	Segregate from 4-6	None
8. Mixed Filled bedding waste containing 4-6	Any mixed filled bedding waste containing one or more of items 4, 5 or 6.	Yes	Hazardous – Infectious H9	Disinfect and decontaminate	Wash, launder

4.4 Ensuring safe input into the manufacturing process

4.4.1 UK

The BS EN 14065:2016 Textiles - Laundry processed textiles - Biocontamination control system provides an appropriate framework to handle and safely deal with biocontamination from waste filled bedding. In order to minimise the risk of cross contamination and harm to workers, it is essential to decontaminate hazardous filled bedding waste prior to further processing.

Washing or laundering methods provide the appropriate technology to render hazardous filled bedding waste non-hazardous allowing for safe onward processing.

4.4.2 France

The following norms provide an appropriate framework to handle contaminated duvet waste in France:

Waste polyester duvets reuse:

Sanitary requirements for incorporation in insulation products
December 2021



- Norm NF EN 12935 of November 2001 sets a standard for hygiene and cleaning of feathers and duvets³².
- Norm EN NF 14065 contains the Risk Analysis Biocontamination Control (RABC) method for cleaning textiles professionally to avoid biocontamination³³.
- Norm FD D90-217 from May 2007 on duvets and similar objects recommends good practices for the design and use of duvets for children³⁴.

→ **Relevance to the waste duvets sanitisation and transformation**

Whichever the starting material and sanitisation process, the waste must be non-biologically hazardous when it becomes a secondary raw material for the manufacturing process. At the end of the process, it should also comply with various healthy standards that were previously covered (emissions of particulates, presence of chemicals, etc.). if some hazard remain then the manufacture must ensure workers' protection and that further process will eliminate the risk before putting a product on the market.

³² Norm [NF EN 12935 of November 2001](#),

³³ Norm [EN NF 14065](#),

³⁴ Norm [FD D90-217](#),



5 Mapping risks, costs, and availability of waste duvets

In order to make rational decisions about the waste streams, a mapping of the **risks, costs** and **availability** of each waste category will be presented. This mapping will serve to decide where the input material will be sourced and what risk mitigation procedure is appropriate for the level of risks posed by different of wastes. Generally speaking, four primary waste streams have been identified

- The **pre-consumer stream** which arises from the manufacturing process of bedding and upholstered items
- The **post-household** stream, where the bedding has been disposed of by individuals after use;
- The **post-commercial** stream, where the bedding has been disposed of by hotels, hospitals, boarding schools or similar entities;
- The **post-sanitisation** stream which may arise from a variety of players but is expected to primarily come from professional laundry services.

5.1 Pre-consumer waste

5.1.1 Characteristics

Pre-consumer waste is produced during the manufacturing process of bedding and upholstered items. It will vary in its form and composition depending on the production stage during which it is generated. Waste generated at the earlier stages of production is likely to arise from dust extraction and process losses during blending. Much of this waste is removed from the system as dust and as such will have a fibre size that is too small to be used in insulation. The most useful materials in this waste stream will comprise trimmings and off-cuts arising further down the production line.

5.1.2 Risk posed

Pre-consumer bedding waste is the waste from duvet, pillow or cushion manufacturers that has **never been exposed to customers**. It therefore does not present any biological risk due to such exposure. As such, workers and downstream insulation material are safe will not need any sanitisation.

5.1.3 Availability

Availability of such waste is unclear prior to discussion with industrial bedding manufacturers. Indeed, it would make sense for the manufacturers to reinsert any scrap back into the manufacturing process. However, it would be useful to discuss this directly with manufacturers to determine whether or not they generate waste that could be used to make duvet waste-based insulation products.

5.1.4 Cost

The cost of buying pre-consumer waste will depend on partnership agreements between bedding manufacturers and insulation manufacturers. The cost of collecting the waste should be relatively low, considering there should be few manufacturing plants compared to waste disposal centres, hotels, hospitals or laundry facilities.

Using pre-consumer waste bedding saves sanitisation expenses as the bedding doesn't present a biological risk due to human exposure and was supposed to be conditioned for use as new bedding, which meets safety requirements.



5.2 Post-household waste

5.2.1 Characteristics

Post-household waste arises when households change their bedding. There is no standard history of sanitisation the bedding has gone through.

5.2.2 Risk

Post-consumer filled bedding waste is at risk of biocontamination. These could occur pre and/or post-disposal depending on where the materials are stored while they await or following disposal. Cross-contamination from material contact during collection, bundling and storage may also arise.

Therefore, the **highest level of risk** must be assumed. The level of biological risk associated to this waste source should be considering that the consumer has never washed their duvets, pillows, cushions, etc. unless a specific sorting procedure is created in order to judge the level of risk of a waste items and sort it appropriately.

5.2.3 Availability

Estimating the amount of bedding waste is difficult because consumers dispose of them in general waste facilities, recycling facilities or even illegally abandon them in public places. One way to estimate the volume of bedding waste generated every year is to look at **sales**: around 25 million upholstered items are sold every year in France for example³⁵; a similar amount is expected to be sold in the UK. This gives an order of magnitude for the amount of waste that could be generated yearly.

Only the waste found in specific bedding skips could be easily used by an insulation manufacturer or through a specific partnership with a waste operator (collector or sorter). This type of waste bedding might be a little more difficult to obtain given the diffuse nature of the source.

5.2.4 Cost

The cost of acquiring and using this waste stream will depend on a variety of factors including the cost of buying. Three modes are possible depending on specific arrangements or contracts passed with waste handlers: the waste is paid for as it is considered a resource, the waste is given for free as the insulation manufacturer provides a waste removal service or the insulation manufacturers is paid to dispose of it as he is effectively a waste valorisation company.

5.3 Post-commercial

5.3.1 Characteristic

Post-consumer commercial waste arises from sites of multiple occupancy such as hotels, boarding schools or hospitals that use large quantities bedding. This category does not include the waste generated by their on-site laundry or by contracted laundry services to an industrial laundry, it is treated in the next section (5.1.5 Post-Sanitisation waste). Instead, this waste stream would contain uncleaned used bedding items that were unfit for use or were disposed of as part of a predetermined replacement plan.

5.3.2 Risk

For post-commercial waste bedding, the history of sanitisation the bedding has gone through depends on the type of entity (hospital, hotel, school, etc.), the country regulations (France, UK) and the company policy for that entity (health and safety chart, internal protocol, etc.). However, unless the specific contamination level has been specified by the waste producer or has been certified by a waste collector/sorter, this waste stream has to be considered has to be considered biocontaminated by default.

³⁵ [Oreillers, couettes, duvet, bons à recycler](#),



5.3.3 Availability

The scale of the site using or laundering the bedding provides a central point for concentration of waste material which has the potential for making the logistics of collection easier and in turn reducing collection costs. It is also likely they will or have access to appropriate separation, segregation and decontamination practices and technologies.

While actual figures and logistics can only be understood by asking commercial entities directly, it can be assumed that the availability of post-commercial bedding waste is a larger and more predictable volume than post-household waste. Indeed, commercial entities dispose of their bedding more often on average and rely on predictable internal policies and processes to determine when and how to dispose of it.

5.3.4 Cost

The cost of buying the waste from commercial actors will depend on specific partnership agreements. The cost of collection is relatively low if the waste is collected from industrial laundry facilities and relatively high if collected from more locations, as is the case for collecting from in-house laundry services in commercial entities (such as hotels, hospitals or boarding schools) or from the commercial entities themselves. The cost of sanitizing is avoided if the waste is collected post-sanitisation.

5.4 Post-sanitisation waste

5.4.1 Characteristics

Post-sanitisation waste is a particular sub-type of the above post-commercial type which includes solely clean used waste. This stream may arise from any commercial or professional laundry industry or from in-house laundry services (in hotels, boarding schools, military camps, etc.). In this stream, bedding items would be cleaned in line with a specific regime until the items were deemed unfit for purpose (condemned) or were disposed of as part of a predetermined replacement plan.

5.4.2 Risk

If the bedding item has been washed to professional standards in accordance to the risk management plans (Table 3) then no biocontamination is to be expected from this waste and its prior history is irrelevant.

5.4.3 Availability

The amount of waste available is hard to quantify without a proper interrogation of industrial laundry companies. However, qualitatively speaking, logistics of acquisition will be facilitated given the point source of the resource.

5.4.4 Cost

As with other streams, acquisition of this type of waste will depend on specific agreement with laundering companies. It is likely the price of the resource will be low given an insulation manufacturer would withdraw a waste the company would otherwise have to pay to manage.



6 Choosing an appropriate waste stream: risks vs costs

In order to determine which waste streams should be considered as sources of the waste bedding used in the BIO-CIRC project and by insulation manufacturers for production of 100% polyester or mix polyester insulation production, an opportunity matrix was put together. It includes risk, cost and availability in each case are given a score between 0 and 3 with 0 being the most desirable and 3 the least:

- 0: no risk/cost
- 1: low risk/cost or high availability
- 2: medium risk/cost/availability
- 3: high risk/cost or low availability.

Then, the average score of each waste stream is calculated so that an overall ranking of streams can be established.

Waste stream	Access		Contamination risk		Expected Cost	Opportunity score
	Source entity	Availability score	Expected waste class	Risk level	Cost score	
Pre-consumer	Bedding item manufacturer	3	Clean filled bedding (unused)	0	2	1,67
Post-household	Waste collectors and managers	3	Assumed mixed bedding waste	3	2	2,67
	Recycling centres	2	Assumed mixed bedding waste	3	1	2,00
Post-commercial	Commercial entity (hotel, school, hospital, etc.)	2	Assumed mixed bedding waste	3	2	2,33
	Waste collectors and managers	1	Assumed mixed bedding waste	3	2	2,00
Post-sanitisation	Waste collectors and managers	1	Clean filled bedding (used or condemned)	0	2	1,00
	Professional laundry organisation or in-house services of commercial entities	1	Clean filled bedding (used or condemned)	0	1	0,67

Figure 1 : Opportunity matrix based on expected accessibility, contamination risk and cost (scores range from 0, best, to 3, worst). The score is the arithmetic mean of the other three scores. The matrix indicates that the most interesting waste stream is the one that is directly provisioned at professional laundry facilities.



→ Relevance to the waste duvets sanitisation and transformation

Sur la base de cette classification, les partenaires de BIO-CIRC recommandent de mettre en place des circuits d'approvisionnement grâce à :

- Des partenariats avec des producteurs importants et réguliers comme les hôtels, leur rythme de renouvellement de la literie est fixe et peut généralement nécessiter moins de décontamination.
- Des partenariats avec des centres de gestion des déchets où une benne dédiée à la literie peut être placée. Bien que la literie puisse nécessiter une décontamination plus importante, elle sera également facilement concentrée.



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