

HELCOM Guidelines to handle EPS and XPS on building and demolition sites


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Guidelines to handle EPS and XPS on building and demolition sites

1. Introduction – what is the objective of the guidance document

This guidance document provides a structured approach for the most sustainable use and management of Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) in construction and demolition settings to minimise emissions to the environment. For completeness it also addresses the best practice for the handling of EPS Packaging waste, which can then subsequently be used as a valuable raw material for new EPS construction materials. These measures will also therefore contribute to recycling and thereby reducing needs for combustion or landfilling.

The Guidance document is based on research in existing studies regarding EPS and XPS at building sites, as well as leading assessments of EPS and XPS in the marine environment. Recommendations furthermore include recommendations collected from a number of EPS associations in the Baltic Sea region, thereby creating a unique document combining science with best available on the ground practices, which if effectively implemented can reduce EPS and XPS littering.

The guidance has been written together with the representatives from the European EPS Industry.

At the end of this guidance (Appendixes IV-VI) some general information about use and recycling provided by the European EPS industry has been attached. This can be used for inspiration when having stakeholder dialogue on proper collection and sorting of polystyrene foam.

The guidance document refers to Polystyrene Foam insulation and EPS packaging, and only specifies EPS or XPS insulation materials, if the recommendation in the guidance is specifically related to that material. The use of XPS packaging is not recommended.

It should further be noted that to the extent that other plastic foam materials are used at building sites, the recommendations covered by this guidance document are equally relevant to these materials. Simply replacing polystyrene foam with other foam materials may not have an overall positive environmental impact. It is therefore always important to reflect on what material best serves the purpose and compare the overall performance of the possible materials against each other, including looking at the environmental profile of the materials.



Figure 1. EPS/XPS at a typical building site (source: IVH, EUMEPS, NEPSA and EPS-branchen).

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3. Executive Summary

These HELCOM guidelines is the implementation of the HELCOM Recommendation 42-43/4 on reduction of EPS and XPS emissions.

This guidance document provides a structured approach for the most sustainable use and management of Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) in construction and demolition settings to minimise emissions to the environment. It also addresses the best practice for handling of EPS Packaging waste. The measures will in general contribute to recycling and thereby reducing needs for combustion or landfilling.

The guidelines starts with a general description of measures covering all insulation materials. Then there is a division into several separate situations ranging from planning of a building, handling at the construction site, collection to possible recycling of EPS/XPS. The individual guidelines contain practical solutions and ways to handle EPS and XPS during the different uses and stages in the lifecycle.

The different guidelines are written in a way so they can be handed out e.g. to those working at the different construction or demolition sites.

At the end of this guidance (Appendixes IV-VI) some general information about use and recycling provided by the European EPS industry has been attached. This can be used for inspiration when having stakeholder dialogue on proper collection and sorting of polystyrene foam.

4. Understanding polystyrene foam.

Expanded Polystyrene (EPS) is a lightweight material, consisting of 98% air and 2% polystyrene (plastic). It is widely used in the construction industry due to its excellent insulation properties, low weight, and good moisture resistance. As an insulation material, EPS contributes to more energy efficient buildings and it is also very easy and safe to install. As a packaging material it serves as a transport packaging for white goods / electronics due to the cushioning properties of the material, and for food such as fish due to its insulating properties.



Figure 2. Close-up of an EPS insulation board (source: IVH, EUMEPS, NEPSA and EPS-branchen).

Extruded Polystyrene (XPS) is another polystyrene foam insulation, with very similar properties to EPS. XPS typically has higher cell density. Consequently, XPS is more rigid, which may make influence choice of material where a high compressive strength is relevant.

EPS is manufactured using a special raw material containing a blowing agent (typically pentane), whereas XPS is extruded at the factory, where the blowing agent is added in the extrusion

process. While the materials are produced in different manners, EPS, Styrofoam, polystyrene is often used interchangeably for polystyrene foams. EPS is globally a small volume plastic (when compared e.g. with PE, PP, PC, PET etc), and accounts for only 3% of the plastic resin produced in Europe. The exact volume of XPS insulation is included in the total PS raw material volume, which is of a similar size as EPS. The total polystyrene foam plastic volume therefore accounts for between 4-6% by weight of all the plastic resin produced in Europe.¹

Polystyrene foam is assessed as a separate category in beach litter studies, which evaluate marine litter based on item counts, rather than weight or volume. According to Lassen, et. al.; *"In Denmark and Poland, 12% and 4%, respectively, of the total plastic beach litter are registered in categories that are dominated by EPS, while in Sweden, Estonia, Finland, Germany and Lithuania, EPS constitutes less than 1%."* (p. 75), however as Lassen, et. al. writes; *"The exact size or weight of the items was not reported. Due to the low density, EPS/XPS would likely account for a smaller percentage if expressed in terms of weight, as has been demonstrated for river transport of plastics where EPS/XPS accounted for about 1% by weight but 14% of the particles."* (p. 15). According to the Survey of polystyrene foam (EPS and XPS) in the Baltic Sea, the total release to the Baltic Sea was assessed to be in the range of 10-100 tons annually. By comparison Boucher, et. al. assessed that the total annual plastic leakage to the Baltic Sea is in the range of 12-60 thousand tons, with a midrange of app. 27.500 tons. Which indicates that polystyrene foam is actually a very minor part of the marine pollution in the Baltic, as it accounts for between 0.02 - 1% based on weight.

Polystyrene foam is lightweight and floats on water, and therefore tends to wash up on beaches where it is rather visible and easily recognisable.

EPS as a material is easily recyclable and it can be mechanically recycled many times over without adding new chemistry during the recycling process. The challenge is correct sorting of the EPS waste and subsequent transport to recycling facility. This transport may require densification of the material (see Appendix VI – Recycling of EPS). If the EPS is not collected for recycling but instead mixed with other waste fractions, it can be incinerated or there is a risk of the material being landfilled and then subsequently becoming litter if the landfills are not adequately managed.² Clean EPS construction and packaging waste can be mechanically recycled (back into EPS products), and if the waste is contaminated then it can be recycled either by a dissolution process back to polystyrene, or by chemical recycling back to the monomer, from which new virgin polymer can be produced.

XPS is typically used in single use food packaging applications, which complicates effective collection and subsequently recycling. In the construction sector, XPS can just as easily as EPS be collected for recycling, when talking about cut-offs from new builds.

For both types of polystyrene foam the proper collection and sorting of the material from demolition waste is more complex, as the recycled material is typically less valuable. They are both recyclable, although facilities to recycle the material into recycled materials have limited capacity at present.

Prior to 2015 the use of legacy flame retardants was mandatory in a number of countries, which puts certain requirements on how to handle the material. If a demolisher is certain that the EPS

¹ https://plasticseurope.org/wp-content/uploads/2022/10/PE-PLASTICS-THE-FACTS_V7-Tue_19-10-1.pdf

² Landfills for EPS and XPS demolition waste containing legacy flame retardants is prohibited by European law. However landfilling for EPS packaging and polystyrene insulation foams from new-build or demolition without legacy flame retardants may be applied in some countries.

is installed after 2015 or otherwise certain is does not contain HBCD, it is possible to recycle EPS demolition waste into EPS light weight concrete, even if the material is dirty.

In cases where the material cannot be recycled it should be incinerated for energy recovery.

5. General measures for all construction materials

The guidance document is focused on the proper management of polystyrene foam at construction sites, this requires implementation of principles that should be enforced for all construction materials, as all materials used at a construction site could potentially become litter and should be as best possible be given a second life in a circular economy.

Hence all construction materials need to be properly managed to ensure that the waste created throughout the construction process is collected for recycling. Otherwise, there is a resource loss to society and the overall benefit of using insulation is reduced as resources are lost.

The general measures are developed based on recommendations from a study Hold Norge Rent and the Norwegian EPS Association³ in combination with polystyrene specific and general recommendations found on the internet and through informal stakeholder consultation.

Therefore, all construction projects should consider the following measures for all fractions:

a) Plan to prevent pollution in the design phase

Measures to prevent pollution should be promoted by decision-makers early in the process, to have the best possible effect throughout the system and the project. At an early stage in the design phase, it should be planned how pollution can be reduced. Concrete examples to reduce pollution include entering into agreements with suppliers about the return of packaging and using reusable packaging and prefabricated elements where appropriate. Prefabricated elements can minimize offcuts from adjustments at the project site and can be suitable for facade panels, among other things.

Information and experiences from other projects should also be used to reduce pollution. Demolition contractors are often familiar with which building elements and construction methods pose the greatest challenges during dismantling, rehabilitation, or demolition. On the other hand, they are also aware of the factors that make dismantling, rehabilitation, or demolition easier and lead to less pollution. It is important to consider how the building at a later stage can be disassembled for recycling.

b) Include pollution in the project's risk assessment

Risk assessment is performed in a number of areas within a project and should also include measures to reduce pollution. Risk can be defined as a product of probability and consequence. In a risk assessment, undesirable events are defined, and it is assessed how the probability and consequence of undesirable events can be reduced to lower the risk. An example of a measure that can be implemented to reduce the likelihood of pollution is to have good routines that also ensure that conditions such as weather and climate (for example, snowfall, leaf fall, and wind) do not lead to pollution. An example of a measure that can be implemented to reduce the consequence if pollution occurs is to have high construction fences as they are in many cases used in e.g. Germany with fabric or close mesh chicken wire that goes all the way down to the ground, especially in areas where pollution occurs; break rooms, smoking areas, waste containers, and during intermediate storage of materials.

³ <https://holdnorerent.no/wp-content/uploads/2022/11/EPS-og-XPS-Rapport-2022.pdf>

c) Put pollution on the agenda from the start of the project, establish a good cleaning culture, and perform regular cleaning rounds

By being conscious from the start of the project, pollution can be put on the agenda and a good cleaning culture established within the project. The survey shows that the scale of what is considered pollution changes with the focus on pollution and the degree of tidiness. By regularly discussing pollution in meetings, raising awareness of the challenges associated with pollution, and collectively finding solutions, each individual will gain greater insight and motivation to keep the workplace tidy. A specific area to focus on is conveying the message that the work is not finished until the cleanup is done.

Regular cleaning rounds are also an effective measure to reduce pollution. Two areas that should be particularly focused on when it comes to cleanup are around waste containers and in areas where materials are stored temporarily. Once an area is polluted, there is also a lower threshold to continue polluting if it is not cleaned up. By incorporating regular cleaning rounds both within and outside the project area, smaller elements of pollution will also be noticed and cleaned up after the larger elements have been addressed. Additionally, tidiness is contagious. In cases where the main contractor has cleaned up the project area, subcontractors have often followed suit and cleaned their areas.

If clients set requirements for proper waste management, it is more likely that the contractors will follow these requirements. Cleaning rounds should also be included in agreements with subcontractors.

d) Include pollution in the deviation system and maintain regular dialogue with the actors

As part of the internal control system, construction and civil engineering projects should have a deviation system. By also reporting pollution findings in the deviation system, the pollution is registered and taken seriously, and the actors responsible for the pollution can clean up. Actors can be rewarded, for example, as "subcontractor of the week" based on tidiness and health and safety. It is more likely that tidiness will be achieved, and pollution reduced if the actors are involved in finding solutions to problems, rather than being told what to do.

The survey shows that visible environmental responsibilities on the project site who are available as sparring partners and who set a good example in terms of tidiness contribute to reducing pollution. By pointing out a challenge and asking how it can be solved together, ownership of the problem and the solution is achieved, and trust is created between the roles.

e) Facilitate proper waste management

Proper waste management at the project site requires adapted intermediate storage solutions for waste and good routines for labeling and emptying waste containers. It is also essential that the waste generated at the project site ends up in waste containers. In most cases, it will be advantageous to use closed containers/solutions so that the waste does not blow away. Use of container, which can be closed, will for all waste fractions minimize unwanted contamination, as people are less likely to dispose incorrect waste streams into the closed containers.



Figure 3. Collection of EPS cut-offs at a building site (source: IVH, EUMEPS, NEPSA and EPS-branchen).

As intermediate solutions, big bags and other solutions may be applied to ensure a transportable collection point. In case of polystyrene and big bags, it is important that these are closed efficiently and then separately stored appropriately to prevent wind dispersing the material. Such storage could be in transport containers.

The number and types of intermediate waste storage stations should be adapted to the activity. To facilitate as best as possible, it should be possible for the work groups to set up their own intermediate waste stations as needed.

Time pressure and uncertainty are two factors that can lead to waste being left next to the containers if one does not know how the waste should be sorted. The waste can remain for a long time, contributing to pollution. Pollution can be reduced by having clear labeling of waste containers with example pictures/illustrations of what can be placed in the container. In addition, there can be a separate area for uncertain fractions to highlight the uncertainty and to increase competence over time.

Waste management often varies more from phase to phase in a project than from project to project. Therefore, the person responsible for emptying containers must have a good dialogue with the work groups along the way, so that the planning of ordering and emptying containers and expected waste fractions are followed up and adapted to the different phases of the project.

A measure to reduce pollution from demolition waste during demolition inside buildings is to use a tight waste chute to ensure that the waste actually ends up in the container.

6. Recommendations for Polystyrene Foam Construction applications

a. Planning phase

All construction projects, whether new builds or renovations, require efficient planning. During the planning phase it should already be clear that only the most sustainable products will be used, and all employees on the job site should be made aware of the importance of minimising any emissions to the environment.

The choice of materials should be based on EPD's (Environmental Product Declaration) and a holistic analysis of the entire building, not the individual materials themselves.

Planning is also important when sourcing the EPS insulation; the correct product needs to be selected for each application as the requirements are different e.g. in an ETIC system (External Thermal Insulation Composite System) than when using the product in floor or roof applications.

Choice of EPS material – the first decision to be taken is whether material with flame retardant is necessary or not. This will depend on both the application and the regulatory requirements in force in the country where the project is being implemented. The most widely used flame retardant (FR) today is polymeric FR⁴. Polymeric FR is neither toxic nor bioaccumulative, posing no risks to the environment⁵ (unlike the Polymeric FR, HBCD, which was used until 2015 and other monomeric FRs which some producers are still using today). If flame retardant material is required, **only material containing the polymeric FR should be used.**

Irrespective of the presence of FR or not, there are two different types of EPS materials available on the market – white and grey. Grey EPS contains graphite which increases the insulating performance by app. 20%, allowing 20% less material to be used to deliver the same thermal performance. There is thus the benefit of lower loss to the environment because of the use of less material, or alternatively the benefit to the environment of better insulation performance using the same volume of material.

Grey EPS should be preferentially selected, if – and only if – other required properties (such as compressive or tensile strength) can be guaranteed

Material with recycled content may have same or better overall environmental performance, and choice between materials should be based on a overall assessment. The product developments in regards to EPS materials with recycled content is rapidly developing and may be different from the time of publication of this guidance.

The higher the density of the material the lower the benefit of the graphite, so for high density EPS, white may be preferable. Furthermore, for some applications the increased thermal performance does not warrant a switch to grey EPS, e.g. radon prevention plates, foundations, etc. It should be considered if the waste management and sorting of the EPS waste will be more efficient and better if all EPS insulation is of the same kind, i.e. flame retarded and/or grey vs. non-flame retarded and/or white.

⁴ CAS: 1195978-93-8

⁵ Dr.. Christian Sinn, Dr. Christoph Semisch, Prof. Dr. Michael Braungart, and Dr. Peter Möhle: Flame Retardant for the Effective Recycling of Expanded Polystyrene (EPS), Fachzeitschrift für Abfall und Ressourcenwirtschaft 51. Jahrgang Oktober 2019 Seite 481 –524

Limit storage time of unused EPS materials - The storage time for unused materials of EPS and XPS should be limited at the project site through efficient delivery and waste management. Planning the construction process to limit the storage of EPS, especially unwrapped materials, is an easy way to avoid EPS becoming litter and prevents inadvertent damage to the material, which could lead to a need for replacement. If possible, store material indoors (see below for further recommendations regarding storage and winds).

Design for disassembly (DfD) – consider ways to incorporate design for disassembly in the construction process. As this will allow for the easy recovery of products, parts and materials when a building is disassembled or renovated. The DfD process is intended to maximize economic value and minimize environmental impacts through reuse, repair, remanufacture and recycling.

Choice of EPS vendor - According to the report “Survey of Polystyrene Foam (EPS & XPS) in the Baltic Sea” published by the Danish Fisheries Agency and the Ministry of Environment and Food of Denmark (Lassen et al. 2019) there is a potential for littering throughout the entire value chain, wherefore choice of EPS vendor can substantially reduce the total risk of leakage to the environment. Choice of vendor should include consideration of the following:

- Have both the raw material supplier and the converter comply with the Operation Clean Sweep (OCS) procedures, which ensure minimal loss of pellets during manufacture, transportation, and handling.⁶
- Is the EPS converter applying the principles documented in the EUMEPS “Guide to Good Manufacturing of EPS” which outlines how to minimise any potential emissions at all stages of the conversion process.
- Is the converter prepared to commit to take back any unused EPS boards along with cut-offs which might result on the construction site. There are a number of schemes, such as EPS Cycle, which are designed to ensure that any unused material gets efficiently collected and recycled.

EPS vendors should only be selected if they can prove a positive response to these 3 considerations.

b. On the construction site

As well as ensuring all employees on the building site are aware of the importance of minimising any waste or emission to the environment, the recommended actions may be grouped into three categories:

- **Storage and loss prevention of the polystyrene foam insulation boards** - It is important that polystyrene foam boards are properly stored to prevent loss of the materials, for instance during storms or heavy winds. Ideally, they should be stored within the building, or in other sheltered area (e.g. surrounded by machinery or construction vehicles); where this is not possible, in the event of a forecast of stormy weather, the boards should remain within their packaging whilst stored, and might be secured with lashing straps or ropes, or weighed down using e.g. heavy wooden pallets. Nominating a single person as responsible to secure all stock in event of a storm forecast will help to minimise any boards being blown away or damaged. If the construction site is able to be fenced (e.g. with chicken wire) this will also help to prevent any boards which might get damaged

⁶ It is expected that certification and auditing will be possible for OCS in the future. It may even become a regulatory requirement.

from escaping the building site. This makes it easier for any fragments of damaged boards to be collected, or hoovered up, and then passed on for recycling.

- **Application practices** – some polystyrene foam boards have to be cut on the building site. This should be done on a level and solid surface that is protected from the wind, offers sufficient space, and is easy to clean. Earth and grass surfaces are not suitable. A broom or vacuum cleaner should be readily available such that all small pieces and any loose particles or dust are collected and placed in a collection bag stored nearby. For cutting it is recommended to use a hot knife (or hot wire cutter) which provides a cleaner cut without tearing or crumbling the material, which can happen if e.g. a regular handsaw were to be used. There are several types of polystyrene foam cutters available, including handheld knives for shape cutting and larger table models for slicing, and some specially developed devices with attached suction which enable any dust to be collected whilst cutting.



Figure 4. Worker using a hot wire to cut EPS (source: IVH, EUMEPS, NEPSA and EPS-branchen).

- **Sorting and handling of any waste** – EPS waste is 100% recyclable, and should therefore be carefully collected, ideally keeping grey and white EPS separate. All fragments / leftovers should be collected in designated bags or containers, ensuring no contamination from other materials such as tape, labels, or other non-EPS substances. Due to its large volume and low weight, it is often advantageous to compact or densify the EPS waste before transporting to a recycling centre; for the larger building sites it could be helpful to organise that a mobile compactor be brought on site to handle the waste EPS. Many suppliers of EPS insulation boards offer a take back system, although they may only be able to take back material from their own production. The possibilities for pick up, reverse logistics, value of the waste, cost of logistics etc. should be agreed with the supplier in advance of placing the order for insulation boards. XPS insulation is equally recyclable.



Figure 5. Mobile EPS compactor in use (source: IVH, EUMEPS, NEPSA and EPS-branchen).

- **Clean as you go** – if polystyrene foam is cut using a hot wire, then it is not any more prone to littering than other insulation materials, however the litter may spread faster due to the light weight of the material. It should therefore be picked up as soon as possible after the processing is completed. Ideally this should happen directly after cutting. This can be achieved through a “clean as you go”- culture at the building site, or via a more structured process for cleaning up, so the cleanup doesn’t wait until the end of the workday, but rather spread out throughout the day. For instance, rather than clean one hour at the end of the day, then split up the cleaning to four 15 minute intervals throughout the day.

c. Handling demolition waste

Construction demolition waste can be difficult to handle in a sustainable way because it is often a mix of various materials (concrete, wood, plaster, plastics). It is therefore important to ensure a structural change in demolition process. This is regardless of what materials are part of the process.

For instance, windows, doors and large items should be removed for reuse or recycling. If care is taken during the demolition to separate the old polystyrene foam insulation, then it can often be recycled.

When dealing with polystyrene foam it is important to consider the following:

- Does the building contain the flame retardants – and if so does it contain HBCD? In the case of XPS it is furthermore relevant to consider if XPS could contain CFC-, HCFC or HFC-gasses.
- Where is the EPS insulation located in the building?
- What were the insulation requirements, when the building was constructed?

In several countries the use of flame retardants has been mandatory if polystyrene foam was used as an insulation material. In some countries flame retardants are only required in application above ground, whereas in some of the Nordic countries flame retardants are not required at all. Hence the analysis of whether the building contains flame retardants or not is based on the national building code and building practices in the given country. It should be noted that in countries that does not require the use of flame retardants, then it may still have been used.

In countries requiring the use of flame retardants and if the building is pre-2015 it is very likely that it was insulated with EPS containing the flame retardant HBCD (which has since been classified as a POP and its use has been phased out). For XPS flame retardant may vary for historical reasons.



Figure 6. Example of EPS/XPS demolition waste sorting (source: IVH, EUMEPS, NEPSA and EPS-branchen).

In such cases special considerations have to be taken in order to correctly dispose of the EPS demolition waste.

A general challenge for all construction demolition waste is that it can be difficult to handle in a sustainable way because it is often a mix of various different materials (concrete, wood, plaster, plastics). However, if care is taken during the demolition to separate the old EPS insulation, then it can be recycled.

The European EPS industry has recently proven with the PS Loop demonstration plant that HBCD can be removed from old insulation boards and subsequently destroyed, enabling the resulting recycled polystyrene to be re-used to produce new insulation material. A number of other technologies have also successfully demonstrated that they can destroy the HBCD and allow the polystyrene to be recycled.

The only alternative to the use of these types of technology is to incinerate the HBCD containing EPS in special incinerators which destroy the HBCD with energy recovery. Landfilling of material containing HBCD is not permitted within the European Union. Material containing the newer polymeric flame retardant can be recycled without any problems.

If the demolition waste is suitable for recycling, then it is important, that when a building is being demolished, it is important to separate the polystyrene foam from other materials such as glues, plaster, concrete etc. If the polystyrene foam is relatively clean (e.g. from flat roofs) then it can be recycled mechanically, otherwise it will either need to be recycled via dissolution-based technologies or via chemical recycling.

The only alternative to the use of these types of technology is to incinerate the HBCD containing EPS in special incinerators which destroy the HBCD with energy recovery. Landfilling of material containing HBCD is not permitted within the European Union.

Consequently, it is mandatory to separate EPS waste from the other demolition materials if it contains HBCD, unless it can be sent to incineration together with a mixed waste fraction, and the incinerator can handle EPS with HBCD.

Material containing the newer polymeric flame retardant can be recycled without problems.

A second consideration in the demolition process is to evaluate where the EPS material is located and consider the specific application. Is the EPS separated from contaminating materials, e.g. plaster, concrete, or is it contaminated.

The specific placement of the EPS and the relevant EPS application will have an impact on how easy it is to collect the material for recycling, especially when taking the following factors into consideration:

- 1) When was the building construction or subsequently energy renovated. Older buildings tend to have less insulation material – regardless of what type of material. And since the first up to 1-2 cm of the EPS which have been exposed to dirt, placed on the ground, or otherwise exposed to contamination will be dirty. “
- 2) The total thickness of the EPS installation is important. If for instance the total thickness is 3-5 cm, then ensuring EPS is energy recovered may be a better solution, than trying to clean, sort and recycle the material. On the other hand if the installation contains 30-50 cm of EPS, with only 1-2 cm being contaminated with soil, then recycling is a better solution.

Regardless when demolishing a building and removing the EPS insulation it is important to separate the EPS from other materials such as glues, plaster, concrete etc. If the EPS is relatively clean (e.g. from flat roofs) then it can be recycled mechanically or via PS Loop type technologies. If it is contaminated with other materials, it must first be cleaned or alternatively might be suitable for chemical recycling back to monomer.

SINTEF in Norway is currently (2023-2026) under way with the extensive project on how to effectively demolish buildings containing EPS, and how to ensure that is efficiently recycled. The project is managed in collaboration with the Norwegian EPS association and involves the entire EPS value chain from raw material production, converter factories and recyclers.⁷

While the work at SINTEF is under development, it is likely that the most efficient way to manage EPS construction waste from demolition is to ensure it is collected for incineration. This will allow for processes and actions in this guidance document to be implemented and enforced in a 2-3 year period, while the SINTEF study is being completed, and at the same time strengthening the development of EPS recycling capabilities for contaminated waste.

In projects where the EPS volumes are assumed to be sufficiently large, and where EPS light weight concrete manufacturers can ensure the demolition waste is recycled, then the EPS should be sorted and recycled in this manner. It is expected that the findings from this work may be equally relevant for XPS insulation.

The guidelines and recommendations for polystyrene foam insulation in new build are all applicable to the demolition aspect of this guidance.

⁷ <https://www.sintef.no/siste-nytt/2023/byggenaringen-ma-gjenbruke-plastisolasjon-fra-riving/>

7. Best practice for Packaging waste

There are many ways to ensure that EPS packaging waste is effectively collected for recycling. In several countries EPS recycling rates exceeds 50% and rates have even exceeded 70% and 80% for transport packaging.

Waste packaging regulations are different in all the countries around the Baltic Sea, and there are many different EPR (Extended Producer Responsibility) regulations in the various EU countries. By 2025 all EU countries should have implemented national regulations for EPR for all typers of packaging.

The Guidance for handling packaging waste is therefore based on generic recommendations and suggestions on how to correctly sort and ensure the collection of EPS packaging for recycling. The guidance recommendations allow for a stakeholder dialogue with the PRO (producer responsibility organisation) and waste management companies. (see also Appendix “How To Recycle EPS Factbox”).

The guidance includes recommendations for implementation at the regional level:

- Ensure EPS packaging waste is separately reported on by EPR schemes (or at least in a category for foamed plastics).
- Ensure EPS packaging waste is collected via collection centres.
- Ensure that EPS has a separate EPR fee, which is dedicated to financing circularity and recycling of EPS packaging waste.
- Support the roll-out of EPS take-back packaging systems.

Recycled EPS packaging waste can be used to make new EPS packaging, but also new polystyrene or EPS raw material which is subsequently converted into insulation boards.

a. Take back schemes

Take back schemes are typically based on reverse logistics, which means that waste materials are picked up as new products are delivered. Regulations in future are likely to require control of the supply chain to ensure materials to be effectively recycled.

Since products packaged in EPS will come from multiple manufacturers, the EPS packaging cannot be used directly by local EPS converters in the production of new EPS materials. The packaging needs to be densified (or recycled to EPS light weight concrete – see recycling options). It is however possible for retailers to operate a take back system, where customers can return the EPS packaging to the retailer directly.

The establishment of systematic take back systems is often linked to the general waste collection and a ring-fenced EPR system for EPS packaging (or foamed plastic packaging). National regulation may have specific requirements which impact how packaging should be handled in a take-back scheme, these should always be followed prior to the guidance recommendations.



Figure 7. Properly labeled EPS/XPS waste bins (source: IVH, EUMEPS, NEPSA and EPS-branchen).

b. Separate collection

Separately collected and sorted EPS waste as well as XPS insulation waste can easily be densified and sold to recyclers. The densification should occur in a closed space (indoor) and any fragments should be cleaned up using a broom or vacuum cleaner.

c. Collection and separation

In some countries EPS packaging waste is collected along with other waste plastics. In this case the EPS can subsequently be separated from other streams as for instance occurring at the Site Zero⁸ sorting centre in Sweden, where EPS packaging waste is washed and then recycled, either mechanically or by chemical recycling if the contamination is very heavy (see appendix VI).

⁸ <https://circulareconomy.europa.eu/platform/en/news-and-events/all-news/welcome-site-zero-where-they-take-plastics-recycling-extremely-seriously>



Figure 8. Collection and separation of EPS packaging waste (source: IVH, EUMEPS, NEPSA and EPS-branchen).

8. Implementation of guidelines

These guidelines are intended for widespread use. It is therefore foreseen that their implementation may be conducted differently by the individual Contracting Parties depending on their national situation. The list below is only a list of possibilities and does not indicate who will be responsible.

The guidelines could be used to:

- educate construction and demolition companies and contractors (small, medium and large organisations)
- develop or optimise national and regional legislation.
- further develop / enhance existing EPR schemes.
- educate waste handling companies.
- information campaigns to educate the public.

Administrations could also use the guidelines as a reference or as good examples for other plastics / materials.

9. Overall conclusions

Generally speaking, EPS is a valuable and sustainable material for the vast majority of its applications. When EPS waste is effectively collected and sorted it is easy to integrate in the circular economy.

If the recommendations in this guideline are effectively implemented, then the contribution of EPS as litter in the marine environment of the Baltic Sea area from building and demolition sites will be significantly reduced.

Regarding the specific applications the following general recommendations should be applied.

- **For building and construction:**
 - use grey EPS rather than white when insulation value is important.⁹
 - only use Polymeric Flame Retardant if flame retardant is required in the EPS/XPS.
 - only use EPS loose fill beads for cavity wall insulation in combination with an adhesive, which allows for disassembly and subsequent reuse and recycling.
- **For packaging:**
 - Do not use loose packaging chips made of polystyrene.
 - Avoid the use of single portion sized food service (take-away) packaging of polystyrene, as there is a risk, that this will be mixed with the collected cut-offs and reduce the value when recycling.

For other applications covered by this guidance, EPS/XPS can easily be included in a circular economy.

⁹ Attention should be paid to the overall performance (for ex. for perimeter products water absorption), while it may also reduce the need for building materials if a thinner insulation material is used.

Appendixes

Appendix I: Planning Phase Check List:

Planning Phase Check List:

1. Define the required criteria and requirements of the needed insulation material in the proposed construction design.
2. Is polystyrene insulation the material of choice?
3. Is use of flame-retardant mandatory (for EPS or XPS) for some or all the construction?
4. Is Grey EPS an option in the construction?
5. Engage in dialogue with vendor?
 - a. Ensure the raw material is from a certified for OCS raw material producer.
 - b. Ensure the EPS converter applies the principles of Good Manufacturing Practices.
 - c. Ensure the EPS converter engages in a take back system, such as EPS Cycle.
 - i. If EPS containing polymeric FR is used. Consider if all materials should contain FR to minimise risk of sorting errors.
 - ii. If Grey EPS is used, consider if all EPS can be made of grey to minimise risk of sorting errors.
6. Create training program for employees.
7. Appoint Storm/Strong Wind responsible.

Appendix II: EPS at the construction site

The following section shows specific recommendations for handling EPS at the construction site. Each appendix is a separate fact sheet.

Appendix II.a: EPS- Storage and loss prevention at the construction site

It is important that EPS/XPS is properly stored to prevent loss of the materials, for instance during storms or heavy winds.



Figure 1A. Storage and loss prevention (source: IVH, EUMEPS, NEPSA and EPS-branchen).

The following actions can be taken to reduce the potential for littering:

In case of wind/storm or loss – have an appointed lead: Have a person responsible to securing EPS/XPS when there is a chance of wind/storm as well as a person responsible to ensuring collection of EPS/XPS that has been accidentally lost.

It is recommended that a person in charge of securing is appointed on the construction site, whose tasks are to stay informed about the weather and to lead and distribute the securing task.

Routines in case of wind/storm:

Before strong wind or storm:

- Prevent and minimize damage to outdoor storage of EPS in connection with strong winds/storms.
- In the event of a warning of strong winds or storm, it is recommended that the following measures be implemented at the latest the day before the warning. This can prevent and minimize damage to stored EPS/XPS in connection with storms, and at the same time reduce the risk of EPS/XPS being blown away from the construction site and ending up as waste outside the construction site.

Execution:

- All polystyrene foam insulation should be moved to a sheltered area where possible. If this isn't possible then the polystyrene foam insulation should be stored as secure as possible and in accordance with guidelines for other building materials. Other types should be grouped together in larger fields for outdoor storage, so that the storage appears as large "cubes".
- The "cubes" should be secured with lashing straps or ropes, after which heavy wooden pallets are placed on top of the large pallets.
- Consider laying the coil down where space allows.
- Excess wooden pallets can advantageously be screwed together and used to secure the EPS coil.
- If in connection with the securing work large pallets are found where the packaging is broken, these should either be repackaged and secured or moved indoors or otherwise sheltered from the wind.
- Consider using vehicles, machinery, or trucks parked along the storage to create as much shelter as possible.
- Be aware that materials used as ballast should not pose a risk to the surroundings.

If damage has occurred:

- Damaged EPS/XPS can be delivered for recycling at local recycling stations or to the current supplier. (*see below re: recycling*).

Appendix II.b: Use of a Hot Knife for Cutting EPS:

To avoid waste and the spread of small EPS beads in the environment, it is recommended to use a hot knife or razor blade knife when cutting EPS, rather than a regular handsaw or similar. A hot knife provides a cleaner cut without tearing or crumbling the material. There are several types of EPS cutters available, including handheld knives for shape cutting and larger table models for slicing.

When cut with a Hot Knife, EPS/XPS are the only insulation materials, which can be cut without producing dust.



Figure 2A. Use of Cutting Tools (source: IVH, EUMEPS, NEPSA and EPS-branchen).

Appendix II.c: Cutting at appropriate locations:

Cutting should take place on a level and solid surface that is protected from the wind, offers sufficient space, and is easy to clean. Earth and grass surfaces are not suitable.



Figure 3A. Use of Cutting Tools (source: IVH, EUMEPS, NEPSA and EPS-branchen).

Appendix II.d: Collection bag

Place a collection bag near the cutting area and ensure that small pieces are immediately discarded appropriately: Ensure bags switched, so the materials are appropriately sorted. (see sorting and collection section).



Figure 4A. Collection bags for EPS/XPS waste (source: IVH, EUMEPS, NEPSA and EPS-branchen).

Appendix II.e: Broom or Vacuum

Keep a broom or vacuum cleaner readily available: Particle residues resulting from the processing and installation of EPS should be quickly removed, collected separately, and subsequently recycled. Here, it helps to always keep a broom or vacuum cleaner readily available. Loose particles can be easily vacuumed up and collected separately. For instance, leaf vacuums can be suitable for this.

Appendix II.f: Use of chicken wire

Larger/long term construction sites: Fenced construction sites can consider applying Close-meshed chicken wire of app. 30 cm in height around the construction site. This will assist in capturing smaller fragments from blowing away, and it will therefore be easier to vacuum the pieces up later (see below).

Appendix II.g: Avoid using sanders

Avoid the use of sanders in conjunction with polystyrene insulation, Should sanders be required always use one with integrated suction.
https://www.google.com/search?q=integrated+suction+sander&rlz=1C1GCEU_daDK987DK987&oq=integrated+suction+sander&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIHCAEQIRigATIHCAIQIRigATIHCAMQIRigAdIBCDgyMjNqMGo3qAIAAsAIA&sourceid=chrome&ie=UTF-8

Appendix II.h: Avoid the use of chain saws.

Polystyrene insulation should not be cut using chain saws. If the polystyrene insulation is used in a composite application which needs to be cut and hot wire cutters are not sufficient, then ensure that cutting is done in a enclosed area.

Appendix III: EPS/XPS- Sorting and waste handling.

EPS as a material is 100% recyclable. It is sometimes considered challenging to effectively collect and densify.

EPS is fully recyclable as durable plastic. Separate disposal of EPS cutting waste can be arranged with the site's waste management operator, or it can be collected for energy recovery if it for some reason is not possible to recycle.

Appendix III.a: Correct sorting of EPS Waste:

Polystyrene insulation from new build and renovation as well as EPS packaging is easily recyclable. They should be sorted in in separate waste streams, as described below.

Collect all fragments/leftovers in designated containers. Make sure the materials are clean, meaning does not include tape, labels or other non-EPS substances, odor-free, does not contain non-EPS/XPS plastic foams.



Figure 5A. Correct sorting of EPS waste (source: IVH, EUMEPS, NEPSA and EPS-branchen).

In absence of specific requirements from take-back scheme use the following sorting recommendations to ensure optimal recycling processes.

Sort EPS/XPS waste into separate streams:

- White EPS for packaging
- White EPS for construction
- Grey EPS for packaging
- Grey EPS for construction
- XPS

EPS demolition waste should be collected in a separate waste stream, which should be separate from the XPS demolition waste stream. Both materials may, depending on the age of the material, contain HBCD, but XPS may also contain CFC gasses, and should consequently have a proper waste management based on national requirement and availability of regional solutions.

Compacting/Densification:

Due to its large volume and low weight, sorting out EPS can significantly reduce the number of waste disposals throughout the year. Collected EPS can be recycled.

Compacting or densification of EPS should occur indoors or in a designated container. It may be necessary to have more than one densifier or to ensure densification of only one of the above-mentioned streams (based on volumes).



Figure 6A. Densification for recycling (source: IVH, EUMEPS, NEPSA and EPS-branchen).

Appendix IV: Contribution by the European EPS industry

- Setting requirements for the take-back system

Many converters are already engaged in take-back systems for EPS construction waste. It is worth noting that converters are typically only able to take back material from their own production, as they may otherwise require specific licenses. For ex. Environmental permits may limit take-back opportunities and amounts. It is also worth noting that EPS for construction and EPS packaging may in some countries require separate handling, as some EPS insulation may contain flame retardants.

The below list is in inspiration for dialogue with EPS suppliers regarding a take back system. The list is based on the pan-European system EPS Cycle, which various Helcom-based EPS converters are part of.

Other converters or producers of other construction materials have similar requirements.

Delivery Options:

Converters should agree to receive all EPS waste as described above from their customers at the designated converter location or a location otherwise agreed.

Converters should engage in reverse logistic collection of EPS waste, i.e., collection of sorted EPS in combination with the delivery of a new order.

Converters organize order collection for reasonable amounts of EPS waste, with the cost of transport not included in the take-back scheme.

Requirements for New Pick-Up Order:

Pick up of EPS waste should be based on reverse logistics and should be scheduled as soon as possible. The time frame for such requirements to be specified by the converter and customer prior to the first delivery.

If there is no recurring delivery of EPS from the converter to the buyer, the converter either agrees to receive the EPS waste at the factory/designated delivery point or to organize transport at the expense of the material buyer.

Fees:

Receipt of clean EPS in accordance with Material Requirements should be free of charge.

A pre-determined fee can be charged if clean materials are mixed (e.g., White EPS packaging with Grey EPS for insulation).

An additional pre-determined fee can be collected if the materials are not clean.

Sorting fees are set by the converter prior to receipt.

Other Terms:

The converter may install an EPS compactor if agreed between the parties.

It is recommended that a stand is used to keep bags for EPS waste in place. The converter will recommend what type of stand is used based on the bag requirements and may lend or lease a stand to the user of the EPS material.

Appendix V: Contribution by the European EPS industry

- Fact sheet about Expanded and Extruded Polystyrene (EPS/XPS)
- with a focus on the materials in a Circular Economy

Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) are lightweight, resource-efficient materials, primarily composed of 98% air and 2% polystyrene. Known for their versatility and high performance, these materials are extensively used in construction and packaging due to their excellent insulation properties, durability, moisture resistance, and cushioning capabilities. EPS and XPS contribute significantly to reducing energy consumption in buildings and protecting goods during transport, supporting global efforts toward sustainability.

However, proper handling and recycling of EPS and XPS are crucial to prevent environmental leakage, particularly in marine environments. Despite concerns about their potential to become marine litter, studies indicate that EPS/XPS contribute minimally to ocean pollution compared to other plastics. The following outlines key facts about EPS/XPS in both the circular economy and environmental contexts, showcasing their potential as sustainable materials when managed responsibly.

Facts About EPS/XPS in a Circular Economy Context:

- **Widespread Recycling of EPS Packaging:** EPS transport packaging is already widely collected and recycled across the globe. Recognized by the United Nations Environment Programme as "recycling in practice and at scale," EPS recycling achieves rates of 70-80% in multiple countries. EPS is actively recycled in at least 39 countries across 5 continents, covering a total population of approximately 4.2 billion people. This demonstrates that EPS recycling is not only feasible but also scalable on a global level. Implementing the recommendations in this guidance can further increase recycling rates for EPS packaging.
- **XPS in Food Service and Polystyrene Packaging Chips:** The two polystyrene foam applications are recyclable; however, the volumes are limited, and the applications would require a separate stream. There are multiple materials used in the production of packaging chips, which makes sorting even more complicated. The use of XPS packaging (commonly used for single-use food service items such as clamshells and cups), and polystyrene packaging chips should be avoided. The specific applications are covered by the revision of the PPWR and phased out under the SUPD.
- **High Recycling Rates for Construction Waste:** EPS/XPS cut-offs from construction sites are easily collected and recycled, particularly in regions with take-back systems. For instance, Germany reports a recycling rate of over 65% for EPS construction waste. By expanding such systems, recycling rates for construction materials can continue to rise.
- **Complex Demolition Waste Recycling:** Recycling EPS/XPS from demolition sites can be more complex, as it often involves mixed construction waste. However, by applying the recommendations in this guidance, recycling rates can be improved, ensuring proper end-of-life treatment for all EPS/XPS waste, including legacy materials.
- **Innovations in Recycling:** Recent innovations, such as the PS Loop demonstration plant, allow for the safe removal of hazardous flame retardants like HBCD from older EPS

materials. This enables EPS to be fully recycled, contributing to circular economy goals even in challenging demolition scenarios.

Facts About EPS/XPS in an Environmental Context:

- **Cost and Resource Efficiency:** Due to their composition of primarily air, EPS/XPS are exceptionally resource-efficient, using minimal raw materials while delivering high-performance benefits across various applications. This translates to lower environmental impacts during production and use.
- **Non-Toxic and Non-Hazardous:** Both EPS and XPS are non-toxic and non-hazardous materials, posing no health risks when handled according to supplier guidelines (Lassen, et. al., 2019, p. 13; DGNB, 2024, p. 89). The styrene monomer used in production should be carefully managed at the factory level but does not pose risks in the final product.
- **Safe Management of Flame Retardants:** Prior to 2015, the flame retardant HBCD was used in EPS/XPS products but has since been banned under the Stockholm Convention. Modern EPS/XPS products now use polymeric flame retardants, which are classified as non-hazardous. Proper assessment and management of EPS/XPS containing legacy flame retardants during demolition or disposal are essential to ensure safety and compliance with environmental regulations.
- **Marine Impact:** While EPS/XPS may be mistakenly consumed by marine animals, research shows that these materials do not cause entanglement and often pass harmlessly through the digestive systems of many species (Lassen, et. al., 2019, p. 65). Although ingestion by wildlife is a concern, proper waste management and recycling significantly mitigate this risk.
- **Performance Benefits Over Alternatives:** EPS transport packaging, especially for large items like white goods, often outperforms alternatives such as cardboard in terms of cushioning and protection during transport, making it a superior option for reducing product damage and wastage.
- **Climate Benefits in Construction:** EPS/XPS insulation materials play a vital role in reducing the climate impact of buildings by improving energy efficiency. By effectively insulating structures, these materials help reduce heating and cooling requirements, thereby lowering energy consumption and greenhouse gas emissions.
- **Recycling Reduces Climate Impact:** Recycling EPS/XPS can substantially reduce their environmental footprint. When EPS is recycled within take-back systems, its climate impact can be reduced by up to 90%. Even recycling EPS into raw materials can lower its environmental impact by up to 50%, making recycling a crucial component of sustainable polystyrene use.

Additional Best Practices:

- **Effective Planning to Prevent Pollution:** Proper planning during the design and construction phases can significantly reduce the potential for EPS/XPS becoming waste. Implementing measures such as using pre-cut EPS materials and ensuring secure storage on-site can prevent damage and reduce the risk of littering.

- **Reduced Pollution Through Proper Handling:** Best practices such as using hot knives for cutting EPS and organizing regular clean-up rounds on construction sites have proven to drastically minimize the risk of EPS becoming litter. These steps ensure that any fragments are immediately collected and recycled.

Conclusion:

EPS and XPS are high-performance materials that offer significant environmental and economic benefits when integrated into a circular economy. Their widespread use in insulation and packaging contributes to energy savings and resource efficiency. However, to maximize these benefits, it is essential to handle and recycle EPS/XPS responsibly, reducing the risk of environmental leakage and marine pollution. By implementing best practices, improving collection, and utilizing innovative recycling technologies, EPS/XPS can continue to play a vital role in global sustainability efforts. This guidance provides actionable steps to further enhance EPS/XPS recycling and waste management, supporting a greener future.

Appendix VI: Contribution by the European EPS industry

- How to recycle EPS

There are four different methods to recycle EPS waste

- Direct reuse
- Mechanical recycling
- Dissolution process
- Chemical recycling

In direct reuse EPS waste is only grinded and feed typically into EPS insulation board manufacturing process. This has been done already decades for internal waste, and it is the most preferable option for recycling. EPS waste can also be cleaned and grinded to certain bead sizes after which it can be used for example in light concrete production.

The most common way to recycle EPS and XPS is the mechanical recycling. EPS is very light material and to decrease the transportation costs it should be compacted preferable on the place where the waste has been generated. After compaction EPS waste is transported to a recycling site, where it is grinded and pelletized into recycled polystyrene pellets in recycling extrusion process. Pelletized material can then be used to produce new EPS raw materials or as a feedstock to XPS production. Mechanical recycling process can also use sorted PS waste as long as the number of contaminants is not too high. How much contaminants is allowed depends on the final use of the recycled material.

The challenge in direct reuse and mechanical recycling is that contaminants cannot be removed totally from the product. If high purity levels are needed the sorting and mechanical separation processes are not enough. If that is the case dissolution process can be used. In dissolution PS waste is dissolved to solvent and all contaminants are removed. After removal of the contaminants the solvent is also removed, and polymer is pelletized to PS pellets through the conventional extrusion process. Quality of dissolution recycled material is better than mechanically recycled material, but the cost is higher as well. Dissolution process should be used when waste is too much contaminated to use in direct reuse or mechanical recycling.

If EPS/XPS waste cannot be handled in any of the process described above the last option is chemical recycling. PS can be either depolymerized in a separate process dedicated to use only polystyrene waste or it can be fed into a feedstock cracking process where mixed plastic waste can be used. The products coming out from chemical recycling are either hydrocarbons which can be used to produce Styrene, the main raw material of polystyrene, or Styrene is produced directly. Chemical recycling is increasing fast when all the big petrochemical players are introducing refineries where plastic waste can be used as a feedstock.

Litterature

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