

**WAS-G-EASR-05**

**SEPA guidance: storage and treatment of Waste Electrical and Electronic Equipment**

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## Introduction

This document provides guidance for anyone carrying out the storage and treatment of Waste Electrical and Electronic Equipment (WEEE) under The Environmental Authorisation (Scotland) Regulations 2018 (EASR). It should be read in conjunction with the overarching guidance on Waste Storage and Treatment.

Schedule 16 of the Environmental Authorisation (Scotland) Regulations 2018 sets out minimum standards for the storage and treatment of Waste Electrical and Electronic Equipment (WEEE).

This guidance provides SEPA’s interpretation of Best Available Treatment, Recovery and Recycling Techniques (BATRRT) for WEEE in accordance with Paragraph 3(3) of Schedule 16.

If the activity is listed in Schedule 20 of EASR, it may also be subject to the [Waste Treatment Best Available Techniques (BAT) Conclusions](https://www.sepa.org.uk/media/594490/bat-conclusions.pdf).

The guidance provided in this document is not definitive, and it does not replace the general obligation to manage each operation in the context of its specific location and characteristics. In certain situations, a higher standard of environmental protection may be necessary, for example, where there are local sensitive receptors.

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## Additional pre-acceptance procedures for WEEE

Further to the general guidance on waste pre-acceptance, the following additional information should be considered for WEEE:

* any treatment already undertaken
* whether the WEEE contains or is likely to contain persistent organic pollutants (POPs)
* confirmation the WEEE (other than domestic smoke detectors) does not contain a radioactive source. If there is a risk of radioactive contamination, for example, in certain types of medical equipment, obtain confirmation that the waste is not radioactive.

 Customers and waste carriers should be told about any specific requirements. For example:

* if reuse is possible – i.e. there are no signs of damage, cables are present etc. - the WEEE items should be handled with extra care so that they can be handled correctly at the destination facility
* if specific measures are required to prevent emissions during receipt and initial storage. For Waste Temperature Exchange Equipment (WTEE), this could include protecting the cooling circuit and exterior casing, preventing the removal of the compressor, checking that any organic or other contents (such as food, drink, wastes) are removed before delivery.

## Additional waste acceptance procedures for WEEE

Further to the general guidance on waste acceptance, the following should be considered for WEEE.

Check Waste Temperature Exchange Equipment (WTEE) on arrival for damage, for example, where the foam can be seen exposed, and leaks, including whether the cooling circuit is complete and includes a compressor.

If WTEE is damaged and the insulation foam is exposed or poses a risk of releasing refrigerant or oil move it to a well-ventilated area, away from any potential sources of ignition and other combustible wastes and prioritise it for treatment (treating it within 24 hours if possible).

 If there is a known risk of radioactive contamination other than the presence of domestic smoke detectors, check the WEEE to determine that it does not include radioactive material.

## WEEE storage - general

Further to the general guidance on waste storage, the following should be considered for WEEE.

Offloading, reception and quarantine areas must have impermeable surfaces with a sealed drainage system.

Outdoor waste storage areas must have impermeable surfaces with a sealed drainage system. The system must collect all surface water run-off and channel it to a sump unless it may be lawfully discharged to the foul sewer or the water environment.

Indoor waste storage areas must have impermeable surfaces with spillage collection facilities.

Use weatherproof covering to store any items that may be re-used as whole appliances or may have components recovered from them for re-use. The type of covering will depend on the types and quantities of waste but must ensure WEEE is protected from the weather.

Use weatherproof covering to store waste containing hazardous material or fluids where necessary to avoid contamination of surface water. This includes:

* lamps and processed fractions
* flat panel display equipment which contains cold-cathode fluorescent lamps (CCFL), and where these are processed by shredding, the shredded fractions.
* broken cathode ray tubes (CRTs) and CRT glass
* shredded WEEE or plastic that may contain persistent organic pollutants (POPs).

Store the following separately from other WEEE in sealed containers to prevent leakage and spillage. Keep containers closed or under cover to prevent the accumulation of rainwater.

* batteries, capacitors and other similar components containing hazardous substances
* any components which may contain residual liquids

Collect and store liquids removed from WEEE in sealed, lidded containers. Keep containers closed when not being filled and store within a bunded area to contain any leakage or spillage.

Clearly mark and sign storage areas, and all clearly label containers (for example, with the relevant EWC code and any hazardous properties).

Label, store and consign containers used to store hazardous waste in line with the properties of that waste.

Collect any spillage or leakage resulting from the storage of WEEE or processed materials without delay. Any containers or surfaces affected by the spillage must be cleaned.

## WEEE storage – specific WEEE types

In addition to the general guidance on WEEE storage, the following further measures should be considered for specific WEEE types.

### Gas discharge lamps

Store lamps in securely robust, sealed and lidded weatherproof containers to prevent the ingress of water, and the release of lamp fragments should any lamps break.

Pack lamps carefully into containers to minimise movement and the risk of breaking. Handle containers of lamps carefully during loading and unloading. Any crushed lamps that have not been treated to remove the mercury should be stored in an airtight sealed drum or airtight sealed heavy duty impermeable plastic bag resistant to punctures. Any bag that does become damaged should immediately be placed inside a secondary sealed container.

Clean and decontaminate any container that has held broken lamps prior to its re-use.

### Flat panel display (FPD) equipment

Store FPDs under weatherproof covering and in such a way as to prevent breakage. They should not be tipped in bulk or stored loose but should be packed to minimise movement. Only store FPDs on pallets if they are stacked and secured to prevent toppling.

Damaged FPDs should be prioritised for treatment to minimise release of mercury vapour.

### Cathode ray tube (CRT) equipment

Handle display equipment containing CRTs and bare CRTs carefully and store in cages, bulk bags or securely on pallets to prevent breakage. Do not tip containers of CRT equipment or bare CRTs in bulk unless enclosure, air extraction and abatement are provided to collect all dust generated. Store any broken CRTs under weatherproof covering.

### Small mixed WEEE (SMW)

Do not mechanically compact untreated and unsorted SMW during storage and transport. This is to minimise the dispersion of pollutants and the risk of fires caused by damage to batteries.

### Photovoltaic panels

Photovoltaic panels should be off-loaded, handled and stored to prevent breakage.

Disconnected photovoltaic panels can generate electricity which can pose a risk of electrocution and/or fire. Store them glass side down and take other precautions to reduce these risks.

### Waste Temperature Exchange Equipment (WTEE)

Store and handle WTEE in a way that protects and prevents damage to cooling circuits, the appliance casing and foam insulation.

Do not store WTEE in a way that puts weight or pressure on to the cooling circuit (for example, by storing it horizontally on its back).  Handle WTEE so as not to damage the cooling circuit. Store WTEE in a safe and stable manner on level ground. Do not stack or store WTEE more than 3.6m high.

Store WTEE under weatherproof covering if it:

* is damaged and the insulation foam can be seen or is exposed
* poses a significant risk of releasing refrigerant or oil

Store WTEE that poses a significant risk of releasing refrigerant in a well-ventilated area a safe distance away from any potential sources of ignition and other combustible wastes.

Where WTEE has been dismantled into panels, store and handle panels in way that prevents damage to, or fragmentation or compaction of, the foam.  Protect dismantled foam panels from the weather (wind and rain), direct sunlight and other sources of heat.

Store compressors removed from WTEE in secure, leak-proof containers to contain any spills from the small residual quantities of oil they may contain. Containers should be:

* closed or kept under cover to prevent the accumulation and contamination of rainwater
* kept away from direct sunlight and other sources of heat

Collect and store blowing agents, refrigerants and compressor oil that has not been degassed in gastight containers that are appropriate and sealed.

Store degassed oil, recovered from compressors and cooling circuits, in above-ground storage tanks or sealed containers. These must:

* have appropriate secondary containment systems
* be located on an area of impermeable surfacing provided with sealed drainage

### Batteries

Batteries removed from WEEE can be;

* sorted into different chemistries on site; or
* sent as a mixture of chemistry types to a specialist battery treatment operator for sorting

Pack and store lithium and lithium-ion batteries removed from WEEE during treatment in a way to minimise the likelihood of electrical shorting, physical impact and overheating.

## WEEE treatment – general

Where WEEE cannot be prepared for reuse, treat WEEE to maximise the recycling and recovery of materials whether at the same facility or by further downstream processing.

Have up-to-date written details of the treatment activities and the abatement and control equipment. This should include:

* simplified process flow sheets that show the origin of the emissions
* diagrams of the main plant items where they have environmental relevance, for example, storage, tanks, treatment and abatement plant design
* details of treatment processes
* an equipment inventory, detailing plant type and design parameters
* waste types to be subjected to the process
* the control system philosophy and how the control system incorporates environmental monitoring information
* the hourly processing capability of waste treatment equipment
* a summary of operating and maintenance procedures

The extent of the information about the treatment activities will depend on the nature, scale and complexity of the facility and the range of environmental impacts it may have.

Have up-to-date details of the actions to take during abnormal operations to ensure compliance with Permit or Registration conditions. Abnormal operating conditions include:

* unexpected releases
* start-up
* momentary stoppages
* breakdowns
* shutdown

WEEE treatment should take place under weatherproof covering such as in a roofed building. Where this is not practicable, for example, due to the large size of the plant, minimise the exposure of WEEE to rain and wind.

Outdoor WEEE treatment areas must have impermeable surfaces with a sealed drainage system. The system must collect all surface water run-off and channel it to a sump unless it may be lawfully discharged.

Indoor WEEE treatment areas must have impermeable surfaces and spillage collection facilities.

Monitor the outputs of the treatment activity. The monitoring should be used to provide evidence that the treatment and removal of these components and substances has been carried out to a satisfactory standard.

## WEEE treatment – removal of specific items

Unless preparing WEEE for reuse, remove all fluids from WEEE along with those substances and components listed in Paragraph 4 of Schedule 16 to EASR.

Removal may be a staged process and may be undertaken at different facilities. If partially treating we partially treated WEEE to another site describe it properly, so the recipient knows which treatments are complete and which still need to be done.

Always remove the following items whole (unless this guidance states specific circumstances where it is not necessary):

* capacitors containing polychlorinated biphenyls (PCBs)
* mercury containing components
* toner cartridges
* components containing asbestos
* components containing refractory ceramic fibres
* components containing radioactive substances
* gas discharge lamps
* cathode ray tubes
* electrolyte capacitors that have a height and diameter greater than 25mm or have a similar volume to a capacitor of those dimensions and contain substances of concern
* batteries and powerpacks

The following as fragments or materials may be recovered after mechanical treatment:

* chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HFCs), hydrocarbons (HCs)
* external electric cables
* printed circuit boards
* liquid crystal displays (LCDs)
* the fluorescent coating in cathode ray tubes (CRTs)
* plastic with brominated flame retardants (BFRs)

Some hazardous items and substances such as asbestos and capacitors containing polychlorinated biphenyls (PCBs) which were used in electrical equipment in the past should no longer be routinely found in WEEE. However, they may still be present in the waste stream. Be alert to this possibility and have procedures in place to identify and remove them for disposal.

Capacitors in equipment manufactured before 1987 may contain PCBs. Assume that they do unless there is clear evidence to the contrary. Capacitors containing PCBs may be POPs waste and must be treated in a way that results int eh destruction of the PCB content.

## WEEE Treatment – Specific WEEE Types

### WEEE Containing BFRs & POPs

Some brominated flame retardants (BFRs) used in electrical appliances are POPs. An industry-led investigation identified the presence of decabromodiphenyl ether (deca BDE) and other polybrominated diphenyl ethers (PBDE) in some WEEE plastics. Identify, separate and remove any plastic containing BFRs for further treatment.

See SEPA Guidance for more information on POPs and WEEE classification - <https://www.sepa.org.uk/media/594293/pops.pdf>

### Gas Discharge Lamps

Gas discharge lamps contain mercury which must be removed. Mercury may be present as a vapour but will also be present in the phosphor powders, glass, electrodes and end caps.

Remove mercury from any gas discharge lamps where it is present including fluorescent tubes, compact fluorescent lamps, high intensity discharge lamps, high pressure sodium lamps and cold cathode fluorescent lamps.

Do not manually break lamps that may contain mercury. Only crush lamps to reduce volume before transport using dedicated crushing equipment designed specifically for that purpose.

Capture and contain mercury vapours, dusts and powders when treating lamps – including if crushing for volume reduction. This includes providing suitable extraction and abatement for the receipt and handling of crushed but otherwise untreated lamps.

Whether crushing for volume reduction or carrying out full treatment, ensure all equipment is sealed and operated under negative pressure. Channel and abate all exhaust gases through a filter system that captures dust and mercury. This will require the use of both a HEPA (high efficiency particulate air) filter and a sulphur-impregnated carbon filter.

Regularly check, maintain and replace as necessary all parts including seals and filters to make sure they remain fit for purpose. Retain evidence of maintenance.

Immediately clean up spillages of broken or crushed lamp material using appropriate equipment, such as an industrial vacuum cleaner with suitable filters, to retain mercury vapour and dust. Used filters and all spill materials that cannot be recycled must be stored in sealed containers, labelled as mercury containing waste and disposed of at an appropriate authorised site.

Keep phosphor powders separate from recycled materials to minimise contamination by mercury. Store removed phosphor powders in airtight sealed containers.

Treat lamps containing metallic sodium so that no metallic sodium remains.

Printed circuit boards and other plastic from lamps may contain flame retardants. Manage these in accordance with SEPA guidance on WEEE and POPs.

To demonstrate effective treatment SEPA recommends the following monitoring should be carried out on the fractions derived from lamp recycling.

* Recycled materials including glass, plastic and metal fractions sampled and tested for mercury at least once every six months with a limit value is 10mg/kg total mercury for glass and plastic and 100mg/kg for metal.
* Phosphor powders sampled and tested for mercury at least once every six months with a limit value of 200mg/kg total mercury.

### Cathode Ray Tubes (CRT)

Cathode ray tubes may include high concentrations of lead oxide in the neck glass (~40%), funnel glass (~20%) and solder glass or frit (~75%). The phosphor powders coating the screens contain compounds of transition or rare earth elements, often zinc or yttrium. The plastic casings as well as cables and printed circuit boards may contain BFRs that are POPs.

Take steps to minimise the uncontrolled breakage of CRTs and remove the following items:

* activated coatings from screens
* printed circuit boards greater than 10 square centimetres in area
* capacitors identified in Paragraph 4 of Schedule 16 to EASR
* plastics containing BFRs
* external electrical cables

The plastic casings of CRT TVs and monitors are known to often contain high concentrations of BFRs including POPs. Cables and printed circuit boards may contain them too. Manage CRT equipment and all separated plastic from CRT equipment in accordance with SEPA guidance on WEEE and POPs.

Separate panel glass (low lead content) from the neck, funnel and frit glass.

Take measures to minimise the release of activated coatings, particularly when the CRT is broken to remove the electron gun.

Split the screen from the funnel and then remove the activated coatings.

Only mechanically process equipment containing CRTs if the process can achieve effective separation of the panel glass from all of the activated coatings so they are removed as a separate fraction.

Mechanical processing of CRT equipment or the crushing of CRT glass must be provided with an adequate dust extraction and abatement system to make sure dust release is prevented or where that is not possible, minimised.

To demonstrate effective treatment and where crushed panel glass is sent for recycling, SEPA recommends the following monitoring should be carried out:

* lead (as lead oxide) every six months with a limit value of 3% lead oxide
* sulphide every six months with a limit value of 5mg/kg sulphur

### Flat Panel Displays (FPDs)

Many FPDs use cold-cathode fluorescent lamps (CCFLs) which contain mercury. Unless a display is clearly identified as having a plasma screen or a screen backlit by LED or organic LED (OLED), treat all FPDs as though they contain cold cathode fluorescent lamps. The plastic casings as well as cables and printed circuit boards may contain BFRs that are POPs.

When treating FPDs remove the following items and materials:

* cold cathode fluorescent lamps (CCFLs)
* liquid crystal displays
* printed circuit boards greater than 10 square centimetres in area
* capacitors identified in Paragraph 4 of Schedule 16 of EASR
* plastics containing BFRs
* external electrical cables
* batteries (where the FPD forms part of a portable device)

If manually removing CCFLs, remove CCFLs carefully to minimise breakage and release of mercury. If mechanically removing CCFLs, do this in a way that avoids any contamination of other fractions with mercury.

Whether using mechanical or manual processes, use appropriate air extraction, abatement and filter systems to capture dust and mercury vapour. This will require both a HEPA filter and a carbon filter.

Only shred whole or partially dismantled FPDs containing CCFLs where:

* there is no fugitive release of mercury
* all releases are channelled and abated to capture dust and mercury vapour
* recycled outputs are not contaminated by mercury to a significantly greater extent than those produced by manual treatment

Once removed, CCFLs should be treated following the guidance on treating lamps containing mercury. Where that treatment does not follow on immediately after removal, pack CCFLs to prevent breakage and store them in securely lidded and weatherproof containers.

Remove broken lamps from the working areas. Collect any residues from broken lamps using an industrial vacuum cleaner with suitable filters to retain mercury vapour and dust. Store all broken lamp debris in appropriate, air-tight containers, until they can be treated in line with the guidance on gas discharge lamps.

The plastic casings of FPD televisions and monitors, as well as the cables and printed circuit boards, are known to often contain BFRs including POPs.

To demonstrate effective treatment SEPA recommends the following monitoring should be carried out on the fractions derived from the mechanical removal of CCFLs from FPD equipment, or the shredding of equipment containing CCFLs:

* all recycled material fractions sampled and tested for mercury at least once every 6 months with a limit value of 1mg/kg total mercury
* phosphor powder and other fines for disposal sampled and tested for mercury at least once every 6 months with a limit value of 200mg/kg.

### Small Mixed WEEE (SMW)

SMW can consist of many different categories of WEEE, including those requiring specific forms of treatment such as gas discharge lamps and temperature exchange equipment containing refrigerants.

Some appliances found in SMW are known to contain high concentrations of POPs in casings, cables and printed circuit boards.

Remove the following items from SMW before mechanical treatment:

* any WEEE or component containing a fluid, such as oil filled radiators
* any components containing mercury such as fluorescent lamps and mercury switches
* any WEEE containing any CRT display or a FPD greater than 100cm2 in area
* any WEEE containing asbestos or refractory ceramic fibres
* any WEEE or component containing radioactive substances
* any WEEE containing CFCs, HCFCs, HFCs or hydrocarbon gases, such as small refrigeration equipment, portable air conditioners and dehumidifiers
* batteries from any WEEE that uses a battery as its principal power source where that can be done without the use of specialist tools – for example, where the batteries are external or where they are intended to be replaced by the user during use
* any non-WEEE items that may contain fluids or hazardous substances, such as petrol.

Remove the following items from SMW before mechanical treatment unless the specific process makes sure they remain whole and intact, and will be removed following treatment:

* capacitors identified in Paragraph 4 of Schedule 16 of EASR
* ink and toner cartridges

Remove the following from SMW, before or after mechanical treatment:

* external electrical cables
* printed circuit boards from mobile phones and other devices if greater than 10 cm2 in area
* batteries other than those identified above, provided the remain intact and identifiable.
* plastics containing BFRs

If mechanically treating SMW, provide and use an adequate dust extraction and abatement system to minimise dust release.

To demonstrate effective treatment SEPA recommends the following monitoring should be carried out on the fractions derived from treated SMW

* the physically finest non-metallic fraction – sample and test for mercury at least once every 6 months with a limit value of 1mg/kg of mercury and 100mg/kg of cadmium.

### Large Domestic Appliances (LDA)

LDA that may be treated in conventional metal shredders is limited to only:

* washing machines
* vented and condensing tumble dryers
* dishwashers
* cookers

Have effective procedures in place to ensure that other types of WEEE are removed from mixed loads of LDA before it is treated by shredding including:

* fridges, freezers and any other Temperature Exchange Equipment
* heat pump tumble dryers
* any WEEE that contains oil or other liquids
* any WEEE that is POPs waste

Remove the following items when treating LDA, before or after mechanical treatment, provided any capacitors remain whole and intact:

* capacitors identified in Paragraph 4 of Schedule 16 of EASR
* printed circuit boards if greater than 10 square centimetres in area
* external electrical cables
* plastics containing BFRs
* batteries

### Photovoltaic Panels

Photovoltaic panels may contain hazardous substances such as lead (in solder), cadmium telluride and compounds of selenium (in the semiconductor layer of non-silicon based photovoltaic panels).

Establish, maintain and use a process for identifying non-silicon based photovoltaic panels.

Remove the lead from all photovoltaic panels and the hazardous semi-conductor layer from non-silicon based photovoltaic panels.

To demonstrate effective treatment SEPA recommends the recycled glass fraction should be sampled and tested at least once every 6 months for cadmium with a limit value of 10mg/kg cadmium.

### Post Shredding Treatment

Use a range of separation technologies to further segregate and purify shredded fractions of WEEE. For example, eddy-current separators, electrostatic separators, and density separation, either at the shredding facility or elsewhere.

Fully characterise and classify fractions produced by these processes.

Where materials originate from WEEE that was POPs waste, fractions of plastic containing brominated flame retardants must be managed as POPs waste.

Where materials originate from WEEE that was not POPs waste, fractions of plastic containing brominated flame retardants must be assessed to determine if they are POPs waste.

Fully characterise and classify (including for POPs) process solutions and washings from density separation processes before determining suitable disposal options.

Only use waste codes for single material outputs, for example plastic, where the treatment involved is aimed at producing a pure material fraction.

Assess at least once every 3 months how much BFR containing plastic is present in any fraction destined for recycling.

## Types of Waste Temperature Exchange Equipment (WTEE)

Waste Temperature Exchange Equipment (WTEE) includes:

* fridge and freezer appliances – domestic, commercial and industrial, for example, fridges, chest freezers or chilled display cabinets
* portable air-conditioning appliances
* heat pump tumble-driers (including combined washer-dryers)
* de-humidifier appliances that use cooling gases
* appliances that dispense cold products (for example, water coolers, ice cube dispensers)

WTEE contains refrigerants, blowing agents and oil, which must be removed during its treatment. They may also contain mercury switches and capacitors over 25mm.

Waste fractions and residues resulting from the treatment of WTEE (with most likely List of Waste codes) include:

* refrigerants and blowing agents (14 06 01\* if containing fluorinated compounds or 14 06 03\* if not containing any fluorinated compounds)
* treated polyurethane insulation foam (19 10 06 or 19 02 10)
* ferrous scrap metal, for example iron and steel (19 12 02)
* non-ferrous scrap metal, for example aluminium and copper (19 12 03)
* plastic, for example polystyrene and rubber (19 12 04)
* glass (19 12 05)
* mercury switches (16 02 15\*)
* compressor oil (13 02 08\*)
* spent activated carbon (06 13 02\*)
* shedder light fraction (19 10 04 or 19 10 03\*)
* plugs and cables (16 02 16 or 16 02 15\*)
* capacitors over 25mm (16 02 16 or 16 02 15\*)
* compressors (16 02 16 or 16 02 15\* if containing hazardous substances)

These codes and descriptions are likely to be appropriate for uncontaminated, separate fractions of relevant wastes. Consider and use alternative codes for other contaminated or mixed fractions of waste, where appropriate.

The refrigerants and blowing agents in WTEE may include:

* chlorofluorocarbons (CFCs)
* hydrochlorofluorocarbons (HCFCs)
* hydrofluorocarbons (HFCs)
* volatile hydrocarbons, for example pentane, propane and butane (VHCs)
* other refrigerants, for example ammonia
* other blowing agents, for example carbon dioxide

The fluorinated substances (CFCs, HCFCs and HFCs) are referred to in this guidance as volatile fluorocarbons (VFCs).

The type and quantity of refrigerant and blowing agent contained in WTEE varies depending upon the age, size and type of appliance. WTEE manufactured before 1995 typically contains CFC and HCFC refrigerants and blowing agents.

After 1995, these began to be replaced by HFC and VHC refrigerants and blowing agents. Identify the type of refrigerant and blowing agent contained in WTEE from the rating plate on the appliance, if present and legible. This is usually found inside the refrigerator or freezer compartments. The blowing agent marking may also be found on the exterior of the back panel of the appliance or on the compressor label.

Unless the refrigerant and blowing agent can be positively identified, assume the appliance contains VFC gases.

## WTEE Treatment – Overview

The treatment of WTEE can generally be split into 2 stages of treatment.

Stage 1 (degassing) typically involves:

* removing, separating and collecting refrigerant and oil from the cooling circuit of the appliance (including removing and capturing refrigerant from the oil)
* removing and draining compressors
* removing switches, drawers, glass, gas discharge lamps and other internal components

Stage 2 (destruction) typically involves:

* shredding the body of the Temperature Exchange Equipment (including dismantled insulation panels)
* removing and capturing the blowing agent in a contained atmosphere
* separating and collecting the degassed insulation foam, metal and plastic fractions

The foam is usually processed further (for example, ground or milled) to make sure the blowing agent is removed and collected.

The collected refrigerant and blowing agent gases are stored in gas-tight vessels and sent for destruction (usually by high temperature incineration). Some facilities include on-site destruction processes (for example, thermal oxidation).

Some gases that are not VFCs, may be sent for refinement at specialist treatment facilities, and re-sold into the refrigeration industry.

Degassed foam is sent for disposal or recovery, usually landfill or incineration. Some facilities compress or extrude the treated foam to produce pellets, whilst at other sites the milled foam exits the plant as a powder without additional processing.

The separated plastic, metal and degassed oil fractions are sent for recycling and recovery.

### Pre-processing

Before subjecting WTEE to further treatment, remove any:

* external electrical cables
* capacitors over 25mm
* mercury switches

Only remove the compressor from WTEE after it has been checked and confirmed that the cooling circuit has been fully degassed.

### De-gassing

Stage 1 treatment process must use specifically designed equipment (such as a specially designed drill head or piercing pliers) that pierces the cooling circuit of the WTEE in a way that maximises recovery of both oil and refrigerant.

Minimise the amount of oil remaining in the compressor after treatment and check that any remaining oil residues will not drip out from the compressor, unless the compressor is stored in (or over) a suitable covered container designed to drain and capture residual oil

Operating procedures should make sure that compressors are routinely checked and tested to confirm they contain no (or minimal) residual oil before storage. For example, this could be by choosing several compressors at random each day and leaving them inverted, to drip, for an appropriate period. If any compressors drip oil, take appropriate action to improve the treatment process or operating procedures to prevent this happening.

Oil removed from WTEE, including residual oil that has been drained and collected from compressors, will contain significant quantities of dissolved refrigerant. Store the oil within a gastight sealed system or container until it has been fully degassed. This is to prevent the loss of refrigerants to the atmosphere.

Pump the extracted oil into a condensing and separation unit, or equivalent contained system, for degassing (separation of refrigerant from oil).

Transfer the recovered refrigerants to pressurised containers for storage though a fully contained gastight system, before on-site treatment or off-site transfer.

Carry out the degassing treatment process:

* on an impermeable surface with sealed drainage
* in a building or under cover

For WTEE containing ammonia refrigerant for treatment, either:

* make sure that the ammonia refrigerant is removed before destruction
* demonstrate that the stage 2 fridge destruction plant is capable of safely treating fridges that contain an ammonia refrigerant

The treatment plant must be designed and operated to capture and contain the ammonia released upon destruction and prevent emissions to the environment.

Stage 1 treatment plant should be capable of removing all (more than 99%) of the refrigerants and oils from the cooling circuit and compressor of WTEE.

Treatment process should achieve and demonstrate a refrigerant removal and recovery rate of at least 90%.

Degassing process should be designed and operated to make sure that the residual refrigerant content (VFC and VHC) in recovered compressor oil is less than 0.9% weight per weight (w/w), unless the oil is both:

* transferred immediately to a suitable sealed container to prevent fugitive emissions
* sent for further refrigerant recovery or destruction

### Destruction

There should be no prior size reduction of WTEE, other than minimal cutting of disassembled foam panels (for example, from large commercial refrigerators) where this is necessary for them to fit inside the plant. Once cut, these panels must be prioritised for treatment to minimise storage time (treating them within 24 hours if possible).

The destruction process must:

* take place in an enclosed treatment chamber
* be provided with effective extraction and abatement systems that capture blowing agent gases and particulates (dust) and prevent emissions

Treatment must make sure the blowing agent released from the foam is collected and contained in gas tight equipment and vessels. Collect the blowing agent using one or a combination of:

* adsorption on activated carbon
* cryogenic condensation with liquid nitrogen

Store the collected gases and send them to be destroyed off-site, for example, by incineration. Destroying the blowing agent on-site by thermal or catalytic oxidation may be an acceptable alternative.

Prevent and control emissions of dust from the destruction process using an appropriate air extraction and abatement system. Abatement systems should use one or a combination of:

* cyclonic separation
* fabric filtration
* wet scrubbing

If using gas adsorption, the treatment plant should be served by at least 2 filters, operating in parallel, so that at least one is adsorbing whilst the other one is regenerating. During filter regeneration, after removing the blowing agent from the waste gas (for example, by compression and cooling), the treated gas should be fed back into the adsorption system to minimise emissions of any residual VHC or VFC compounds.

The treatment process should recover and collect water separately from the blowing agent. If they are collected together:

* collect and contain the blowing agent and water mixture in gas-tight pressure vessels
* accurately monitor the quantity of water collected with the blowing agent and record this weight for weight (w/w) on a regular basis, excluding this from any blowing agent recovery calculations

Enclosed treatment plant should be designed and operated to control the concentration of gases and prevent the risk of explosion. Do this by one of the following methods:

* inert atmosphere – continuously monitoring and maintaining the concentration of oxygen below the relevant limiting oxygen concentration by injecting nitrogen
* forced ventilation (treatment of VHC equipment only) – continuously monitoring and maintaining the hydrocarbon concentration below the relevant lower explosive limit through forced aeration

Treatment plant should be fitted with appropriate gas detection and monitoring systems to:

* detect any build-up of explosive vapours
* trigger automatic safe shutdown of the plant if the relevant limiting oxygen concentration or lower explosive limit is exceeded

If the treatment process is not conducted under an appropriate inert or forced ventilation atmosphere, take measures to prevent appliances containing hydrocarbon blowing agents (or other flammable substances and materials) from entering the process.

Carry out continuous indicative monitoring of the air contained in plant extraction systems for VFC gases using infrared analysers.

The treatment process should achieve and demonstrate the following blowing agent removal and recovery rates:

* 90% or more, based upon an annual assessment of a selected sample of WTEE
* 80% or more, based upon a monthly assessment of the WTEE treated during that period

If recovered refrigerants or blowing agents are destroyed on-site, for example, using thermal or catalytic oxidation, achieve and demonstrate a 99.99% destruction efficiency through routine process and emissions monitoring.

The treatment process must be designed and operated to make sure that the residual blowing agent (VFC and VHC) content of treated foam is less than 0.2% w/w. Demonstrate this through written sampling and testing procedures and records.

The treatment process should be designed and operated to make sure that the residual content of untreated foam (foam that has not been fully treated to release the blowing agent) in the recovered metal and plastic fractions is less than:

* 0.5% w/w in metal streams (ferrous and non-ferrous)
* 1.0% w/w in plastic streams

These limits apply both to the quantity of foam attached to pieces of metal and plastic and the quantity of loose pieces of foam in the recovered fractions.

The standards referred to are set with the purpose of demonstrating effectiveness of treatment. They are not set to determine whether an output fraction of waste should be classified and described as a mixed waste or separate fraction for onward transfer.

### Monitoring

Monitor the performance of the treatment plant on a continual basis. Record the number and type of WTEE processed through stage 1 and stage 2 treatment processes.

For stage 1 processes, record the number of:

* WTEE by refrigerant type (halogenated, hydrocarbon or other – for example, ammonia)
* defective WTEE (appliance with no compressor or low gas pressure in the cooling circuit)

 For stage 2 processes, record the:

* number of WTEE by blowing agent type (halogenated, hydrocarbon or other, such as carbon dioxide)
* number of WTEE by appliance type (see blowing agent recovery for more information on the relevant types – Type 1, Type 2, Type 3 and 4)
* quantity (kg) of separate foam panel processed

Use an independent laboratory to complete compliance tests and analysis on the waste fractions and residues produced by the treatment process. The laboratory should:

* be appropriately accredited
* use recognise accredited methods if they are available

Because of the high volatility of VFCs and VHCs:

* fill sample containers to the top and close them immediately after filling
* close and seal the containers and vessels that samples have been taken from immediately after sampling
* send all samples containing (or suspected of containing) these substances to the laboratory as quickly as possible – on the same day if possible
* store samples below 4°C whenever possible

### Refrigerant Recovery

Assess plant performance against the refrigerant removal and recovery rate of stage 1 treatment (minimum of 90% recovery) on a 6-monthly basis.

Assess refrigerant recovery using a representative sample of the WTEE treated at the facility. The sample should reflect the range of WTEE types accepted for treatment and include a minimum of 100 intact appliances. Select the WTEE to make sure it is in good condition.

Base this on a mass balance calculation comparing the weight of the WTEE before and after stage 1 degassing (before other parts and components are removed following degassing, for example, compressors), and the mass of refrigerant and oil collected (recording and comparing the mass of the collection vessels before and after degassing).

To calculate the amount of refrigerant collected as a percentage, for comparison to the performance standard, you should use the formula:

(A ÷ (B − C)) × 100 = % recovered

Where, A is the mass of refrigerant recovered (grams), B is the reduction in mass of degassed appliances (that is, mass of appliances before degassing minus mass after degassing (grams)) and C is the mass of oil recovered (grams).

In addition to the detailed 6-monthly assessment, record the total number and type of WTEE processed and quantity of refrigerant and oil recovered.

### Blowing Agent Recovery

Assess plant performance against the blowing agent removal and recovery rate (minimum of 80% recovery) on a monthly basis. More frequent assessment and reporting may be required if the assessed recovery rate falls below the target recovery rate.

Record the total number and type of WTEE processed and the quantity of blowing agent recovered on a quarterly basis. Where WTEE has been dismantled into panels before treatment (for example, cold room panels or large commercial refrigeration units), then record the quantity (kg) of foam treated.

Base the monthly assessment of plant performance on the total number of WTEE and total quantity of dismantled panel foam treated during that quarter. Compare the measured and recorded mass of blowing agent recovered during that month from the WTEE and dismantled panels treated to the theoretical mass available for recovery (based upon the number and type of appliances treated). Calculate the theoretical mass of blowing agent available for recovery using the relevant values from the tables that follow. Exclude recovered water from the calculation of recovered blowing agent.

Base the annual assessment of stage 2 plant performance upon a representative sample of the WTEE treated. The sample should reflect the range of WTEE types accepted for treatment (excluding Type 4 appliances, unless theoretical blowing agent figures are agreed) and include a minimum of 100 appliances. Select the WTEE to make sure it is in good condition, labelled with the type of blowing agent it contains and inspected to confirm there is no visible damage. Compared the mass of recorded blowing agent collected from the treatment of the WTEE to the theoretical mass available for recovery, as detailed previously for the monthly assessment.

**Theoretical foam and blowing agent (BA) content of untreated WTEE by type (in grams):**

**WTEE containing VFC blowing agents**

|  |  |  |  |
| --- | --- | --- | --- |
| **WTEE Type** | **Type 1** | **Type 2** | **Type 3 and 4** |
| Foam content | 3,140 | 4,880 | 5230 |
| Blowing agent content | 257 | 343 | 429 |

The figures above are calculated on the basis that the BA content of VFC foam is 8.2% w/w (82g per kg).

**WTEE containing VHC blowing agents**

|  |  |  |  |
| --- | --- | --- | --- |
| **WTEE Type** | **Type 1** | **Type 2** | **Type 3 and 4** |
| Foam content | 3,300 | 6,300 | 8,300 |
| Blowing agent content | 125 | 239 | 315 |

The figures above are calculated on the basis that the BA content of VHC foam is 3.8% w/w (38g per kg).

**Notes about table data**

Source of data: CENELEC, 2017, Collection, logistics and treatment requirements for WEEE, Part 3-4: Specification for de-pollution - Temperature exchange equipment, PD CLC/TS 50625-3-4:2017, BSI Standards Publication).

Types of WTEE:

* Type 1 are refrigerators with storage capacity no more than 0.18m3 (for example, small under-counter refrigerators)
* Type 2 are refrigerators or combined fridge-freezers with storage capacity from 0.18m3 to 0.35m3 (for example, full height refrigerators and standard freestanding fridge-freezers)
* Type 3 are freezers with storage capacity no more than 0.5m3 or refrigerators or combined fridge-freezers with capacity greater than 0.35m3 and no more than 0.5m3 (for example, freezers, chest freezers and large freestanding fridge-freezers)
* Type 4 are any refrigerators, freezers or combined fridge-freezers with a capacity over 0.5m3 (for example, very large American-style fridge-freezers and chest freezers)

Record (in terms of type and number processed) treated WTEE that is not fridges, freezers or combined fridge-freezers and exclude them from blowing agent recovery rate calculations or determine a theoretical foam and blowing agent content for them. Theoretical blowing agent content of WTEE is calculated by multiplying foam content of WTEE type by blowing agent content (% w/w).

Calculate the theoretical blowing agent content of dismantled foam panels from large commercial or industrial WTEE (for example, commercial refrigerators and freezers used in retail premises) by multiplying the blowing agent content (% w/w) by the weight of panel processed.

For WTEE with a missing door, assume the amount of foam contained in the appliance is 20% lower than the figure in the previous tables for the relevant type. For separate doors, assume the treatment of 5 doors is equal to 1 WTEE of the relevant type if they are the full height and width of the appliance in question. These figures should be corrected for appliances that have 2 doors. For example, for fridge-freezers with 2 doors of approximately the same size, each door would represent 10% of the foam contained in the appliance and 10 doors would equal 1 WTEE.

### Residual Materials

Record the quantity of waste fractions and residues produced by the treatment process. This should include quantities of refrigerant and blowing agents, oil, foam, metals and plastics.

Every quarter, get a representative, composite sample (consisting of at least 3 individual samples) of relevant waste fractions and residues and send them for testing and analysis. This is to assess their composition against the standards. Record the results of the analysis and comparison to the relevant material standards.

Test the waste fractions and residues for the following parameters, quantity of:

* refrigerant in degassed oil (% w/w) – limit 0.9%
* blowing agent in treated foam (% w/w) – limit 0.2%
* untreated foam in plastic fraction (% w/w) – limit 1.0%
* untreated foam in non-ferrous metal fraction (% w/w) – limit 0.5%
* untreated foam in ferrous metal fraction (% w/w) – limit 0.5%

## Point source emissions to air

Contain the waste treatment process to collect, extract and direct all process emissions to an appropriate abatement system for treatment before release.

Identify the main chemical constituents of the site’s point source emissions as part of the site’s inventory of emissions to air. Include the speciation of volatile organic compounds (VOCs) if identified in the emissions inventory and it is practicable to do so.

To reduce point source emissions to air (for example, dust, volatile organic compounds and odour) from the treatment of waste, use an appropriate combination of abatement techniques, including one or more of the following systems:

* Adsorption
* fabric filter
* wet scrubbing
* HEPA filter
* condensation and cryogenic condensation
* cyclone
* electrostatic precipitator (ESP)
* thermal oxidation

Assess and design vent and stack locations and heights to make sure dispersion is adequate.

Where monitoring is required, install a suitable monitoring point.

Procedures must ensure abatement equipment is correctly installed, operated, monitored and maintained. For example, this includes monitoring and maintaining:

* appropriate flow and chemical concentration of scrubber liquor
* the handling and disposal or regeneration of spent scrubber or filter medium

Carry out emissions monitoring when the plant is operating at or near to full treatment capacity.

Depending on the process, the Permit may include emission limits and monitoring requirements for point source emissions to air based on the relevant BAT Conclusions.

**Channelled emissions to air from all mechanical treatment of WEEE**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Standard** | **Frequency** | **Limit** |
| Dust | EN 13284-1 | every 6 months | 5mg/m³ (where it is inappropriate to fit a fabric filter due to the potential effects of deflagration on the filter, the limit is 10mg/m³) |
| TVOC | EN 12619 | every 6 months | - |

In addition, the following monitoring is required from all mechanical treatment of WEEE when the substance concerned is identified as relevant based on an assessment of emissions.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Standard** | **Frequency** | **Limit** |
| Dioxin-like PCBs | EN 1948-1, -2 and -4 | every 12 months | - |
| PCDD/F | EN 1948-1, -2 and -3 | every 12 months | - |
| BFRs |  | every 12 months | - |
| Metals and metalloids excluding mercury (arsenic, cadmium, cobalt, chromium, copper, manganese, nickel, lead, antimony, selenium, thallium and vanadium) | EN 14385 | every 12 months | - |

**Channelled emissions to air from the treatment of WEEE containing mercury**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Standard** | **Frequency** | **Limit** |
| Total mercury | EN 13211 | every 3 months | 2-7 µg/m³. |

Periodic monitoring results should normally consist of the average value of 3 consecutive measurements of at least 30 minutes each. For some parameters, due to analytical limitations, a longer sampling period may be required.

Monitoring frequencies may be reduced if the emission levels are proven to be sufficiently stable over time.

**Channelled emissions to air from the treatment of WTEE**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Standard** | **Frequency** | **Limit** |
| CFCs | follow the procedures in CEN/TS 13649 | every 6 months | 0.5-10 mg/m3 |
| Dust | EN 13284-1 | every 6 months | 2-5 mg/m3 |
| Total VOCs | EN 12619 | every 6 months | 3-15 mg/m3 |
| Brominated flame retardants | should be adapted from BS EN 1948 | annually if the substance is identified in emissions inventory |  |
| Dioxin-like PCBs | EN 1948-1, 2, 4 | annually if the substance is identified in emissions inventory |  |
| Metals (arsenic, cadmium, cobalt, chromium, copper, manganese, nickel, lead, antimony, selenium, thallium and vanadium) | EN 14385 | annually if the substance is identified in emissions inventory. |  |
| PCDD/F (dioxins and furans) | EN 1948-1, 2, 3 | annually if the substance is identified in emissions inventory |  |
| Total VFCs and VHCs (mass emission) | follow the procedures in CEN/TS 13649 | monthly for first 6 months of operation, then quarterly with written agreement | 5g per 100 appliances processed, per hour. Calculate and report this on a pro-rata basis, per 100 appliances processed per hour. |

## Point source emissions to water and sewer

Identify the main chemical constituents of the site’s point source emissions to water and sewer.

The sealed drainage system must collect all surface water run-off and channel it to a blind sump unless it may be lawfully discharged to water or sewer.

Collect and treat separately each water stream generated at the facility, for example, surface runoff water or process water. Separation should be based on pollutant content and treatment required. Segregate uncontaminated water streams from those that require treatment.

Relevant sources of wastewater include (but are not limited to):

* water or condensate collected from treatment processes
* waste compactor runoff
* vehicle washing
* vehicle oil and fuel leaks
* washing of containers
* spills, leaks and leaching in waste storage areas
* loading and unloading areas

POPs may leach or wash out in particulates from some wastes, such as shredded WEEE plastic or granulated cable, if stored without weatherproof covering. Prevent the release of POPs to water or sewer either by providing weatherproof covering or treating the affected water.

To reduce emissions to water and sewer, consider treating wastewater before discharge or disposal using an appropriate combination of treatment techniques, including one or more of the following:

* preliminary or primary treatment – equalisation, neutralisation or physical separation
* physico-chemical treatment – adsorption, distillation or rectification, precipitation, chemical oxidation or reduction, evaporation, ion exchange, or stripping
* biological treatment – activated sludge process or membrane bioreactor
* nitrogen removal – nitrification and denitrification
* solids removal – coagulation and flocculation, sedimentation, filtration or flotation

For relevant emissions to water or sewer identified by the emissions inventory, carry out monitoring of key process parameters at key locations. For example, either at the:

* inlet or outlet (or both) of the pre-treatment
* inlet to the final treatment
* point where the emission leaves the facility boundary

Depending on the process, the Permit may include emission limits and monitoring requirements for direct and indirect discharge to water and based on the relevant BAT Conclusions.

**Direct discharges to a water body from all mechanical treatment of WEEE**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Standard** | **Frequency** | **Limit** |
| TOC | EN 1484 | every month | 10-60mg/l |
| COD |  | every month | 30-180mg/l |
| Total suspended solids | EN 872 | every month | 5-60mg/l |

**Discharges to sewer or a water body from all mechanical treatment of WEEE**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Standard** | **Frequency** | **Limit** |
| Hydrocarbon oil index | EN ISO 9377-2 | every month | 0.5-10mg/l |

**Discharges to sewer or the water environment from all mechanical treatment of WEEE, when the substance concerned is identified as relevant based on the facility’s emissions inventory**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Standard** | **Frequency** | **Limit** |
| Metals and metalloids | various EN standards available | every month | arsenic, 0.01-0.05mg/l  cadmium, 0.01-0.05mg/l  chromium, 0.01-0.15mg/l  copper, 0.05-0.5mg/l  lead, 0.05-0.1mg/l  nickel, 0.05-0.5mg/l  mercury, 0.05-0.5mg/l  zinc, 0.1-1mg/l |
| PFOA, PFOS and deca BDE |  | every 6 months |  |

Monitoring frequencies may be reduced if the emission levels are proven to be sufficiently stable over time.

Monitoring frequencies for discharges to sewer may be reduced if the downstream wastewater treatment plant abates the pollutants concerned.

## Disclaimer

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