Why a further lowering of LPC and UTC threshold values for POP BFRs risks having adverse results for the environment.

The policy objectives of the circular economy and the objectives of a non-toxic world can only be reached by finding an intelligent balance between the two justified interests and EERA hopes to be able to contribute to this debate with this paper.

The discussion over POP BFRs is a discussion that has been running over 15 years in many treaties and legislative regulations. For electronics the PBDE substance group is restricted since the first version of RoHS – some 15 years ago. EERA has questioned the need to have so many legal regulations (RoHS, REACH, POP Regulation, Waste Shipment Regulation) for the same substance group several times.

Fact is that those POP BFRs have been regulated and restricted over more than a decade and that therefore these substances are phasing out, even without changing the goalposts. The proposal to reduce the Low-POP Content threshold for those POP BFRs therefore might sound logic, but it is not. WEEE plastics account for a large volume of highly valuable tech-plastics and the EEE producing industries have pledged to take up large volumes of properly recycled Post-Consumer Recycled tech-plastics from WEEE.

As a consequence the Circular Economy requires more WEEE plastics to be recycled properly and compliantly and this requires more recycling capacities in the EU. The reasons why the capacities of WEEE plastics recycling are insufficient in the EU is related to the facts that (1) most WEEE plastics left Europe undocumented until very recently (and most likely even today) and (2) the legislative landscape for the recycling of these WEEE plastics is so complex and (3) because of these POP threshold discussions that never seem to come to an end.

The WEEE plastics recycling industry is new and had to learn to deal with the separation and environmentally sound management of these separated BFRs. This new industry did learn it and is now showing that in terms of the environmentally sound management of POP BFRs. This mechanical recycling route of WEEE plastics is the best possible route to make sure that these POP BFRs are separated and properly destructed by thermal processes.

The Circular Economy also requires more types of WEEE plastics to be recycled from the complex mix of WEEE plastics. This is only possible through Innovations, which is linked to new technologies to separate and meet the legal thresholds of POP BFRs in recycled articles. Innovations stop when thresholds of these POP BFRs continue to be lowered, as any new technique will have to go through a learning curve. Lowering particularly the Unintentional Trace Contaminant thresholds would have devasting effects on such innovations, that are critical for the Circular Economy.

A major problem with any reduction of the POP BFR threshold is related to the issue of the practical implications to the screening methods. POP BFR screening of the Low POP Content Thresholds in wastes is very complex and, in many cases, not required and in those cases in which these screenings are required, it may be expected that they are very often not performed. The screening of recycled plastic material is easier, but there are limits to the values that can reliably be measured, as the standard EN 62321-2-1 shows. This standard is validated for RoHS threshold values which are 1000 ppm for the substance group of the PBDEs.

The last POP Regulation was published only in June 2019. Beyond the political will to lower threshold values for POP BFRs, EERA only sees disadvantages for the development of the Circular Economy in the EU. As the restrictions have taken place long ago, the levels of POP BFRs lower anyway, irrespective of any further lowering in LPC or UTC values.

It is likely, that WEEE plastics will be driven into undocumented channels, if threshold reductions are taking place and this risks to result in adverse effects on the environment.

For these reasons EERA therefore strongly recommends, that the Low POP Content and the Unintentional Trace Contaminants thresholds for the POP BFRs are not changed from the levels that were decided upon only two years ago and to keep the values as set in the POP Regulation 2019/1021 of June 20th, 2019.

About EERA:
EERA is a professional association for recycling companies dealing with Waste Electrical and Electronic Equipment (WEEE) in Europe.

The vision of EERA is for a circular economy where WEEE is managed as a valuable resource, that is returned into the economy as equipment for reuse or as a raw material that is properly recycled.

A circular economy with market actors cooperating along the value chain, an appropriate and enforced legal framework, better collection processes, treatment based on Best Available Technologies, eradication of illegal practices and product design integrated in a life-cycle approach.

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Annex 1 - The history of this threshold discussion

The topic of LPC and UTC thresholds for PBDE's and HBCDDs is again on the agenda of the European Union. EERA is involved in discussions about BFRs since the first introduction and following versions of RoHS, when the group of PBB's, HBCDD's and PBDE's were first discussed and restricted in EEE products. These discussions come back and again every few years, be it around about single congeners, or as a substance group, be it in the Stockholm Convention, the Basel Convention, in RoHS Directive, or in REACH- or the POP- or in the Waste Shipment Regulations, be it in concentration levels in waste or in products and certainly in different approaches and EERA has questioned at several occasions why one substance group is regulated in so many different legislative rules and regulations.

In 2018, the EU Parliament, voted for a reduction of the UTC POP threshold for Deca-BDE to 10 ppm and this brought huge shockwaves with it within the WEEE recycling community, as this would mark the end of the WEEE plastics recycling as an industry. After a trialogue discussion early 2019, a solution was found by defining recycled material as "articles" and defining a threshold of 500 ppm for Deca-BDE. But the result of this event led to investment decisions for additional recycling capacities to stall, as many investors considered this to be an industry in which investments can be made in vain.

During the COP of 2019, no decision could be reached about the Low POP value for Deca-BDE and/or for the group of PBDE's and the decision was postponed to the next face-to-face COP, that due to COVID is now planned for June 2022. Although the POP Regulation was reviewed and published as recently as June 2019, the EU decided to review thresholds again with a study made by RPA. Early November EERA received the RPA study together with the EU Commission paper, with new proposals for the Low POP Content threshold without any mention of the related Unintentional Trace Contaminant thresholds. This is on the one hand surprising as these two thresholds are interlinked and logical as they follow two different political decision-making procedures.

This topic of POP thresholds has thus been a continuous theme on our EERA agenda for the last 15 years. The most important step has been made some 15 years ago by the restriction of use of these BFR POP substances in electronic products and, as several studies show (the latest was the SOFIES report), the logical consequence of these restrictions is, that the concentration levels of these POP BFRs are reducing constantly.

Restricted POP BFR substances have been replaced by other, permitted, brominated or other flame retardant substances, which, today, are by far the dominating FRs used.
The WEEE plastic recycling industry has learned to deal with the separation of BFRs.

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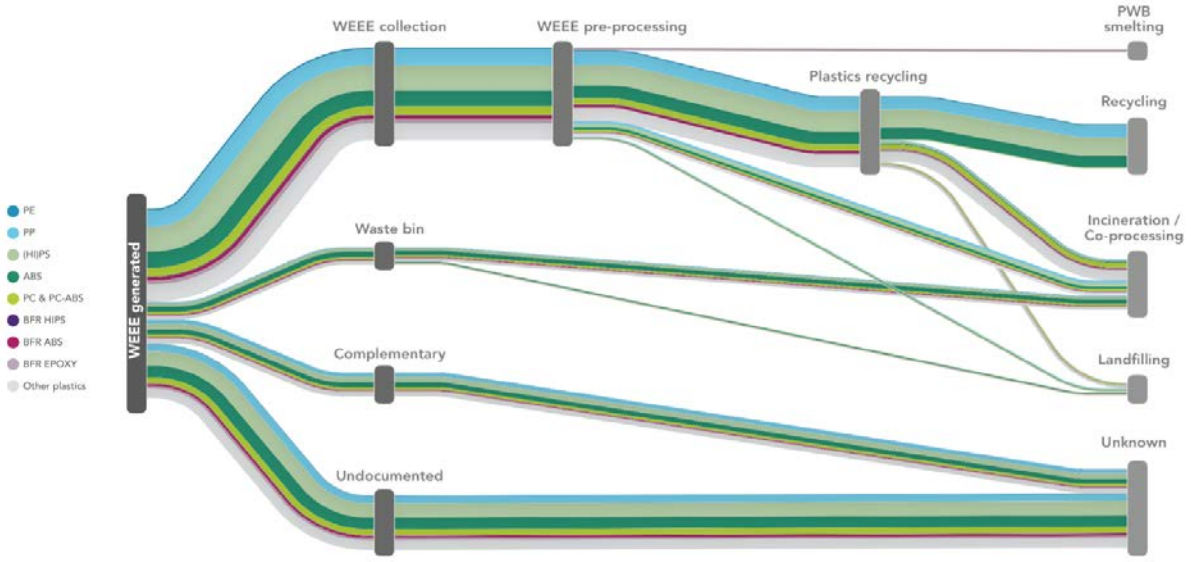
Annex 2 - Volumes and flows and composition of WEEE plastics.

The total amount of plastics used for electronic products in Europe amounts to some 3.1 Mio MTs of plastic, of which some 2.6 Mio MT are estimated to be included in WEEE (Waste of Electric and Electronic Equipment) at their End-of-Life. Unfortunately, only slightly over half of the WEEE plastics are delivered to specialized WEEE recycling facilities, as the mass-flow graph of the SOFIES study shows. This represents some 1.3-1.4 Mio MTs of WEEE plastics.

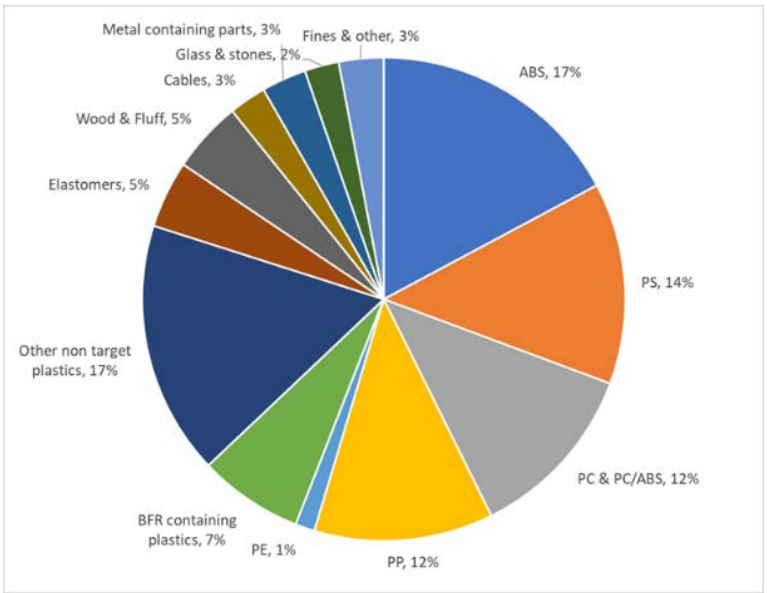


Source: SOFIES Study

The composition of WEEE plastics is a complex mixture of tech-plastics, whereby until recently only 3 plastic types have been recycled until recently, namely ABS, PS, and PP.

Since 2018, PC-ABS was added to this mix of Post-Consumer Recycled plastics from WEEE and further plastic types, such as PC, PA and PMMA are expected to be added to the types of recycled plastics from WEEE in the not-too-distant future.

The development of these new PCR plastic types follows a typical product development cycle, in which teething problems must be addressed, including the separation of POP BFRs. (Return).



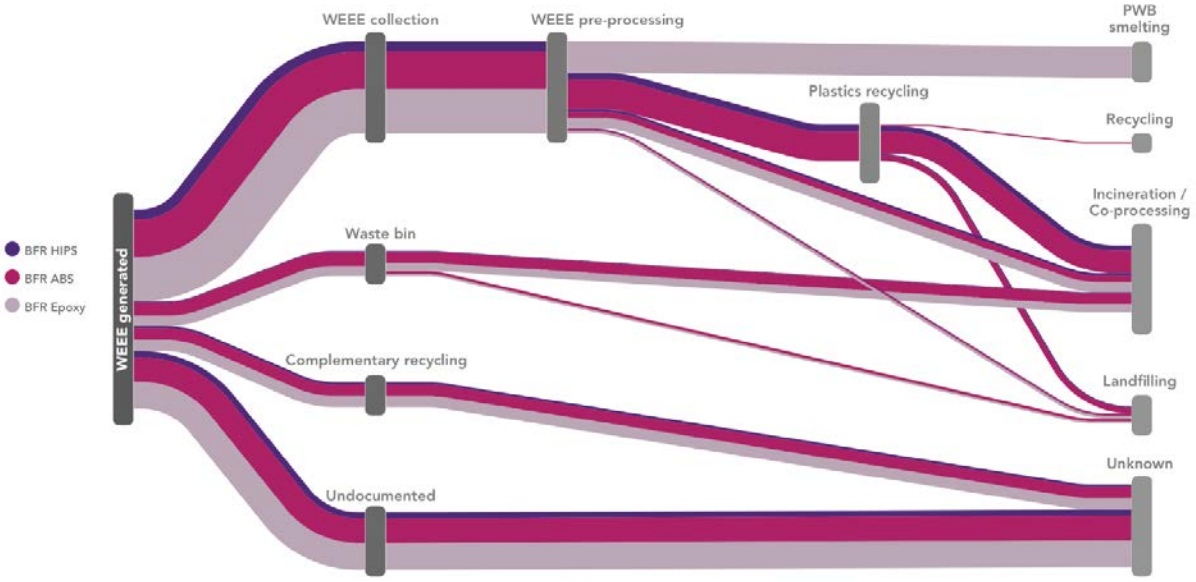
Source: MGG Polymers

Annex 3 - Mechanical recycling of WEEE plastics has huge environmental benefits

Recycling WEEE plastics has major advantages, as the energy needed for producing these Post-Consumer Recycled (PCR) plastics is only a fraction of the energy used to produce virgin tech plastics.

The advantages on the Carbon Footprint are enormous. Per Metric Ton of WEEE plastics that can be recycled, some 4 Metric Tons of CO_2 are saved compared to the same tech plastics produced from fossil sources, as all the energy used to produce these tech polymers matrices is re-used.

But also, in terms of the environmentally sound management of POP BFRs, mechanical recycling is the best possible route to make sure that these POP BFRs are separated and properly destructed by thermal processes. The SOFIES study has made this very clear with the graph below.



Source: SOFIES Study

Some 98% of POP BFR containing plastics officially collected, are separated, and disposed of through official WEEE recycling channels. But currently only 55% of all WEEE plastics are not entering specialized WEEE plastic recyclers.

The most efficient way to make sure that POP BFR levels are reduced quickly is to make sure that these WEEE plastics enter the official WEEE recycling channels. EERA has been asking for many years to make sure that more WEEE enters the official collection channels. In line with the Stockholm Conventions guidelines this has proven to be the best Environmentally Sound Management option.

For that reason, more compliant recycling operations are required in Europe.

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Annex 4 - Insufficient WEEE plastics recycling capacities in Europe.

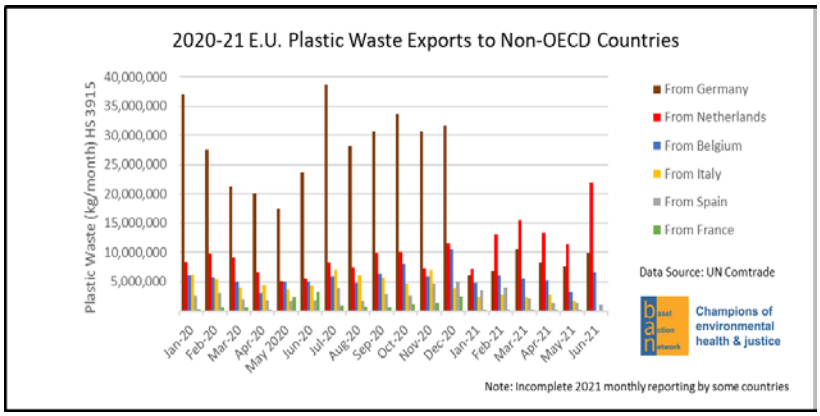
Until only a few years ago, most of the plastics from WEEE disappeared from Europe and most of these plastics were exported to China. The logistic costs for deliveries to China were very low, using the empty container space of the containers that needed to be relocated.

The European WEEE plastics recyclers in these days competed with foreign companies. Since 2018 this changed with the ban on the import mixed plastics in China. This decision resulted in a shift of these flows to other countries, mainly in the Far-East.

This, in combination with the complex waste legislation in the EU, explains why Europe has insufficient WEEE plastics recycling capacities in Europe.

Based upon the "Norwegian proposals" that were introduced into the Basel Convention, new classification rules for the transboundary shipments of mixed plastics, were introduced in the Basel Convention. These rules resulted in the need for Waste Shipment Notification procedures for mixed WEEE plastics. Since the end of 2020, these rules have been embedded in a slightly adapted form, within the EU as well.

The Basel Action network recently published a paper in which the export of plastics from Europe was documented based on statistics.



Plastic Waste Trade Exports to non-OECD countries initially declined with the introduction of these new rules but have been increasing again since. Unfortunately, there are no specific statistics for WEEE plastics, but from discussions with specialized companies exports still take place.

The recycling capacities in the EU need to be increased and investments can only be stimulated by legal stability and the possibility to import the mixed plastics mixes from other EU countries.

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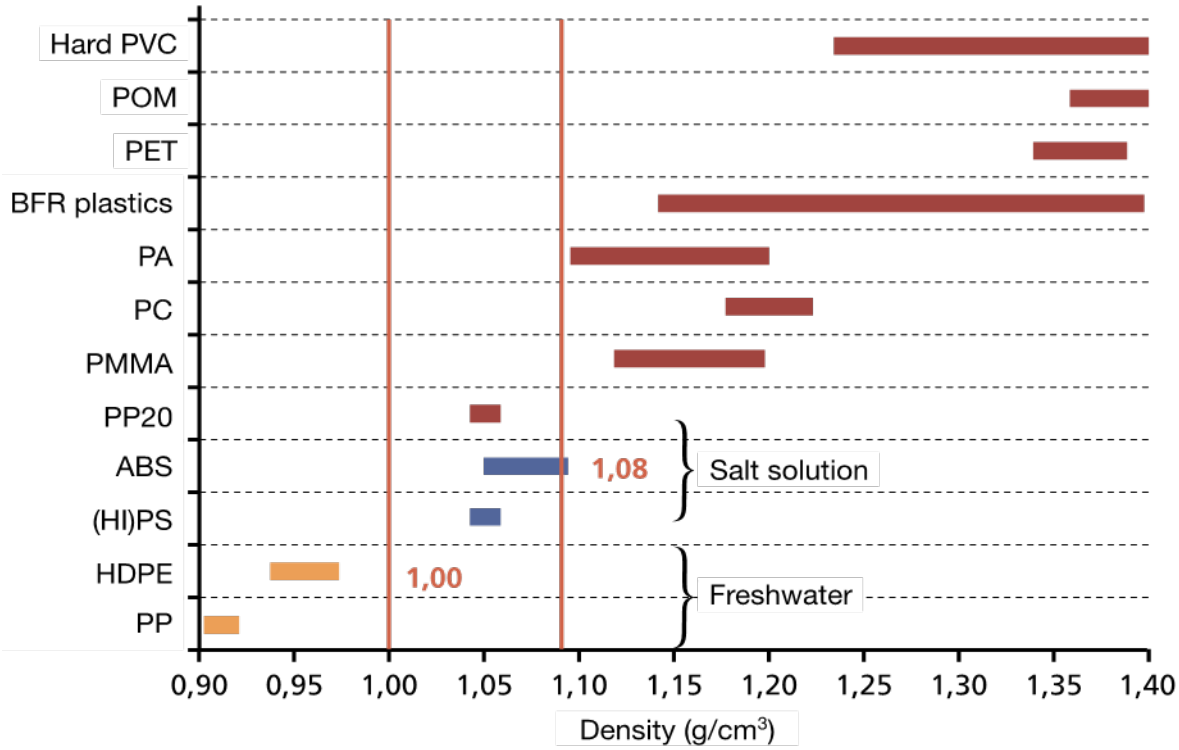
Annex 5 - Separation of (POP) BFRs

The separation techniques of BFRs from WEEE plastics is not possible per substance group or substance congener type. The most frequently technique in terms of WEEE plastics treated is separation by density and this works best for the most frequently recycled plastics PP, ABS and PS, as the graph below shows.



Source Graph: A.Haarman

Density sorting can and has been used as main technique to separate plastics with BFRs particularly for the most widely recycled WEEE plastics PP, ABS and PS. As WEEE plastics have overlapping densities, further separation techniques for obtaining pure polymers are required.

The BFR rich fraction from this density separation includes valuable polymers such as PC, PC-ABS, PA, PMMA as well as basic polymers with mineral fillers. Innovation in the sector of WEEE plastics recycling is taking place to develop techniques to also recycle some of these plastics. Different technologies need to be applied for this purpose. These technologies are likely to consist of high-tech sensor-based techniques and a lot of development work, particularly in developing material libraries, that are still required to make sure that substances of concern such as POP BFRs can be recognized and separated. Sensor based techniques still play a minor role, but a lot of development work is being performed on sensor-based techniques, be it in the form of Near- and Mid-Range Infrared, XRT and/or XRF techniques.

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Annex 6 - Innovations in WEEE plastics recycling

A small proportion of the WEEE plastics recycled are used in new EEE products. The demand for PCR recycled material from WEEE to new EEE products is however growing quickly. The low share of "closed-loop" recycling of WEEE plastics to new electronic products can at least partly be explained by the fact that many OEM producers even set lower thresholds than what is set by law. Lowering legal thresholds further will thus likely even higher requirements set by the EEE industry, thus reducing the uptake of PCR Content from WEEE in new products.

For the Circular Economy it is important that other polymer types are recovered from this highly valuable plastic waste stream from WEEE.

Since 2018, the polymer blend PC-ABS has been added to the plastics from the WEEE plastic waste stream and this development was recognized very recently with the European Plastics Recycling Award, where the Deutsche Telekom was announced winner in the category Automotive, Electrical or Electronic Products with a modem made with a housing made with recycled PC-ABS from WEEE.

One of the members of EERA shared a series of tests that were performed on one new polymer, separated from the WEEE plastic mix. And this test shows very clearly that the current thresholds can perfectly be matched. A bromine content of 1150 ppm (well below 2000 ppm in line with the Cenelec Standard EN-50625) and a POP BFR (PBDE) content of 350 ppm, well in line with the currently valid POP Regulation. Sensor based techniques are new and time is needed to improve the selectivity, be it related to the sensors or in the development of libraries, that need to be developed and adjusted, to cope with interfering other potential additives apart from the BFRs. The separation of POP BFR substances is one of the important topics in this learning curve challenges for new polymers to be separated from WEEE.

Other EERA members are participating in several EU funded research projects (NONTOX, CREAToR and PLAST2bCLEANED), in which these EERA members together with research partners develop several dissolution techniques, which are capable of separating BFRs from the polymers. This allows the recycling of BFR containing plastics and this is indispensable if ever we want to move to a fully circular economy.

The advantage of the dissolution technique is that apart from the polymers, it also allows to recover the elements Bromine and Antimony (on the EU Critical Raw Material list).

Results that our members share with EERA show that with the current state of the developments, the current 500 ppm is still a challenge, but research partners trust that they can achieve it eventually. Further lowering of these limits today will in the best case stall the development of these techniques with a couple of years. In the worst case, development will have to stop altogether, as it might turn out, that it is technically impossible to meet these lowered thresholds. These technologies are today at TRL 4 / 5. At a TRL 7 level it will be clear what will technically be feasible with these new.

A reduced Low POP Level threshold is likely to also result in reduced UTC threshold values and this will have a major negative impact on the development of new plastics to be separated from the WEEE plastics mix, as such innovation developments need time, effort… and a stable legislative environment.

Lowering the particularly the Unintentional Trace Contaminant thresholds would have devasting effects on such innovations, that are critical for the Circular Economy.

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Annex 7 - Screening of Waste and recycled materials on POP BFRs

The recycling of durable products such as End-of-Life Electronics follow a process, that is described in the European TAC guidance document Annex II and article 6.1 of 2002/96:
"Substances, preparations and components may be removed manually, mechanically or chemically, metallurgically with the result that hazardous substances, preparations, and components and those mentioned in Annex II are contained as an identifiable stream or identifiable part of a stream at the end of the treatment process. A substance, preparation or component is identifiable if it can be (is) monitored to prove environmentally safe treatment."

In line with this TAC guideline, the shredder residues from WEEE are treated to recover plastics mix from these residues and this plastics mix is treated by specialized plastic recycling plants. The "target plastics" without substances of concern, such as POP BFRs can be recycled into Post-Consumer Recycled plastics with characteristics that allows these secondary raw materials to be re-used in new electronic appliances or other durable products. There are several techniques that can be used for this purpose, and these are described in the Stockholm Convention Guidance Document on best available techniques and best environmental practices relevant to the PBDEs listed under the Stockholm Convention on Persistent Organic Pollutants.

There is no need to measure any of the POP BFRs on the **Low POP Content Threshold (only applicable to waste)**, if the WEEE plastic material is treated by a specialized WEEE recycling facility – see also the schedule that was published by EERA.

In that case the compliance will need to be tested by the end of the recycling chain on the Post-Consumer Recycled product, before re-entering the Circular Economy as product.
In that case the **Unintentional Trace Contaminant Threshold (applicable on "articles")** is applicable.

If the mixed plastics from WEEE are not delivered to a specialized WEEE plastics recycling company, that will separate the BFR containing plastics from those without, the Low-POP Content thresholds are applicable and need to be measured. As this is complex and cumbersome, it may be questioned how often these measurements are taking place.

The technical screening method how to screen the content of Brominated Flame Retardants is based upon the analysis standard IEC EN 62321-3-1, which is developed to screen RoHS compliance, ie. this standard is thus based and validated for 1000 ppm of Bromine as element. For recycled products this is verified by regular external cross checks at external laboratories, mainly using Gas Chromatography Mass Spectrometry (GC-MS) analyses (see remarks in Annex 10). Currently there is no other screening technique available other than the XRF screening method.

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Annex 8 - How to screen Brom as element using XRF in WEEE plastic waste (Low POP Content).

On large pieces of plastic or in industrial separation machines, XRF can be applied as a yes/no analyzer on the presence of Bromine as element. In that case the technique is used to separate BFR containing plastics from those without. This method is used from time to time for large pieces of housing from dismantling operations such as CRT and Flat Panel TV's.

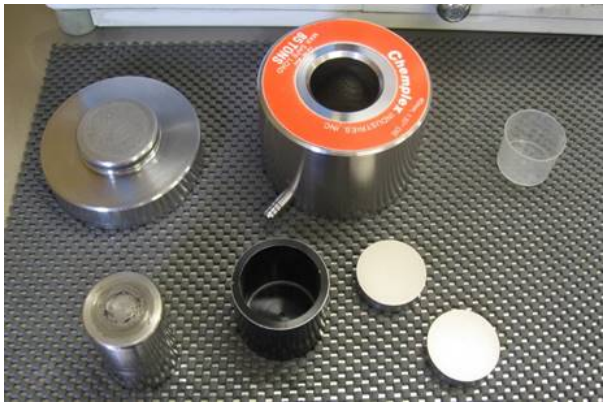
If XRF is used to measure Br concentrations in a shredded mixed WEEE plastics pile, the following steps need to be taken for a valid XRF measurement:

1. There needs to be a representative sample – the Cenelec EN 50625 describes how a representative sample needs to be taken from a pile (for instance for a Batch Test).

2. This representative sample needs to be size reduced to dust – cryogenically (very cold as the plastic would otherwise melt in the grinding process).

3. The dust sample again needs to be reduced in volume until you have the volume to press an “analysis tablet”

4. Tablet press**:** The tablets are pressed with previously finely ground plastic dust into a tablet mould with an electro-hydraulic press with a pressure of 20to. Then the pressed plastic tablet is melted together in the drying oven at the respective melting temperature of the plastic.



5. Only then an XRF measurement can take place.

The reading of the XRF appliance does not necessarily represent the true value of the Br concentration since many different types of additives or other contaminations might be present in the WEEE plastics that can influence the result of the reading.

This is a cumbersome and time intensive screening method and the Cenelec EN-50625 threshold of 2000 ppm for Bromine as element is the currently valid accepted practical threshold, under which it is certain that the thresholds for POP BFR values are not exceeded. (Return)

Annex 9 - How to screen Brom as element using XRF in PCR WEEE plastics (UTC threshold).

For recycled material (defined as "Article" in the POP Regulation) the Unintentional Trace Contaminant (UTC) threshold value is to be applied for the POP BFRs. For WEEE plastics the most important POP BFR is the group of the PBDE's, for which a UTC threshold is 500 ppm is valid. Hexabromocyclododecane (HBCDD), is not found in WEEE plastics.

The screening method using XRF is generally applied by WEEE plastic recyclers on their end-products. The PCR flakes from WEEE are typically blended before and/or during the extrusion process, so that this final product will have been homogenized. Measurements are taking place typically on test-bars.

As bromine is only an indicator for the presence of POP BFRs (most BFRs are permitted substances), the relationship between the Bromine level and the presence of POP BFRs is verified by regular cross checks at external laboratories, mainly using Gas Chromatography Mass Spectrometry (GC-MS) analyses, relating the concentration of the individual substances to the Bromine content.

In the EU funded research project CREAToR, in which two EERA members are participating, a comparative study is in progress between existing standard GC-MS protocols. Intermediate results show that there are substantially different values measured in different laboratories.

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Annex 10 - Why is there only a screening method available for 1000 ppm of elemental Brom?

The question is often asked why the standard for XRF measurement (EN 62321-3-1) is validated for 1,000 mg/kg and what limits its validation level? In the first place we must realize that this standard is developed to screen RoHS compliance, and this explains why the standard is validated for 1000 ppm.

Indeed, on standardized and normed samples the Lower Limit of Quantification (LOQ) it is possible to measure lower levels of bromine. This is not the case for a mix of plastics that can have many different types of additives or that have different surfaces and/or colours, which all can have a major impact on the reading of the XRF analysis equipment. Therefore, the EN62321-3-1 standard has a validated minimum value of 1000 ppm for PBDEs.

Of course, there can be lower readings of an XRF measurement appliance, but that does not mean that this reading is correct. There are no other practical screening methods available to date, but this XRF screening based upon the EN 62321-3-1.

EERA has enquired when this standard and new validations will be adapted and to date, we understand that this is not yet planned.

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