Development of European Ecolabel and Green Public Procurement Criteria for Imaging Equipment

BACKGROUND REPORT
INCLUDING DRAFT CRITERIA PROPOSAL
Working Document

for

2nd AHWG MEETING FOR THE DEVELOPMENT OF ECOLABEL CRITERIA FOR IMAGING EQUIPMENT

Jiannis Kougoulis, Renata Kaps, Oliver Wolf

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Background report including draft criteria proposal
Working Document

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Abbreviations

AHWG	– ad-hoc Working Group
BAT	– Best Available Techniques
BREF	– Reference Document on Best Available Techniques
CEN TC	– European Committee for Standardization Technical Committee
CO_2	– Carbon dioxide
EPA	– United States Environmental Protection Agency
EU	– European Union
GPP	– Green Public Procurement
ISO	– International Standardisation Organisation
MS	– Member State
UBA	– German Federal Environment Agency
dB	– deciBell
DIDP	– di-isodecyl phthalate
DINP	– di-isononyl phthalate
DNOP	– di-n-octyl phthalate
DS	– Dye Sublimation (
DT	– Direct Thermal
ECMA	–European Computer Manufacturers Association
EP	–Electrophotography
IJ	–Ink Jet
ipm	–images per minute
IT	–Information technology
LCA	–Life cycle assessment
MFDs	–multifunctional devices
MFPs	–multifunction products
Sbw	– monochrome printing/copying speed
SI	–Solid Ink
TT	–Thermal Transfer
PJ	–Peta Joule

EEE	–Electric and electronic equipment
TVOC	–Total volatile organic compounds
ISO	–International standardisation organisation
R	–risk phrase
H	–Hazard statement
TBBPA	–Tetrabromobisphenol-A
BBP	–Butyl pththalate
SCCP	–short chain chlorinated paraffins
DIBP	–Diisobutyl phthalate
PBBs	– polybrominated biphenyls
PBDEs	–polybrominated diphenyl ethers–
SDS	–Safety Data Sheets
CMR	–carcinogenic, mutagenic or toxic for reproduction
REACH	–Registration, Evaluation, Authorisation and Restriction of Chemicals
PCs	–Personal computers

1 INTRODUCTION

The European Ecolabel[1] is an element of the European Commission's action plan on Sustainable Consumption and Production and Sustainable Industrial Policy[2] adopted on 16 July 2008. This is a voluntary scheme established to encourage manufacturers to produce goods and services that are environmentally friendlier. The EU Ecolabel flower logo should facilitate recognition by consumers and organizations (i.e. public and private purchasers) of the best performing products in this respect, and making environmentally conscious choices more easily. The EU Ecolabel covers a wide range of products and services, and its scope is constantly being broadened. The process of establishing the criteria proceeds at the European level following consultation with experts and all interested parties. A product or a service awarded with this label must meet high environmental and performance standards.

Green Public Procurement (GPP), defined in the Commission Communication "Public procurement for a better environment"[3] as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured." This is also a voluntary instrument, which public authorities can use to provide industry with incentives for developing and marketing more environmentally sound products[4].

The criteria for "imaging equipment" aim at promoting reduction of environmental damage or risks related to the use of energy (global warming, acidification, depletion of non-renewable energy sources) by reducing energy consumption, environmental damage related to the use of natural resources and hazardous substances, by reducing the use of such substances in imaging equipment devices.

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[1] EU Ecolabel website http://ec.europa.eu/environment/ecolabel/about_ecolabel/what_is_ecolabel_en.htm.
[2] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, COM (2008) 397, available online: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0397:FIN:en:PDF
[3] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Public procurement for a better environment, COM (2008) 400, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0400:FIN:EN:PDF
[4] GPP website http://ec.europa.eu/environment/gpp/what_en.htm

The criteria aim, in particular, at promoting products that have a reduced environmental impact along their life cycle (i.e. global warming, acidification, ecotoxicity, human toxicity, eutrophication, resource depletion, energy consumption), whose performance is resource efficient and energy efficient, and which contain a limited amount of hazardous substances. The criteria furthermore aim at promoting products with low noise levels and that contribute to lower indoor air emissions. Their selection is based on IPTS preliminary work conducted in the project "Development of EU Ecolabel criteria for imaging equipment"[5], stakeholders' feedback to the IPTS first working document for criteria development [6] and input received at the 1st AHWG Meeting in Seville, as well as written comments received afterwards.

Criteria are proposed for the following areas:

1. Paper Management
2. Energy efficiency
3. Indoor air emissions
4. Noise
5. Substances and mixtures in imaging equipment
6. Reuse, recycling and end-of-life management
7. Ink and toner consumables
8. Corporate criteria
9. Social criteria

[5] For details please see the project's website: http://susproc.jrc.ec.europa.eu/ecotapware/.

[6] 1st technical background report available at the project's website: http://susproc.jrc.ec.europa.eu/ecotapware/stakeholders.html.

2 PRODUCT DEFINITION AND SCOPE

The definition and scope of the product group of imaging equipment has been addressed in the respective background document of IPTS "Product definition and scope" report. This issue was the subject of discussion and agreement in the 1st Ad-hoc Working Group (AHWG) meeting.

The product group of imaging equipment is defined by adopting the definition used in the Energy Star label, which matches the one used in the current EU Green Public Procurement criteria as well as the respective one used in the frame of the Ecodesign Directive (EU Ecodesign Preparatory Study for imaging equipment and respective Industry Voluntary agreement). This definition is also used worldwide by numerous Ecolabel schemes. The definition as proposed by IPTS was agreed in the 1st AHWG.

With regard to the scope of the study in general, imaging equipment involves the products marketed as office printers, copiers, multifunctional devices (MFDs), scanners, digital duplicators and fax and mailing machines. From this wider scope based on the outcomes of the market analysis (Technical background Report[7]), the current market situation, technological trends and the discussion among stakeholders in the 1st AHWG, it was agreed to address in the scope of the Ecolabel criteria the products which are: commonly used in the office (household and professional devices), have high market volumes and without significant negative market or trends. The products which fulfil these requirements and were agreed on for the scope of the Ecolabel criteria are: printers, copiers and MFDs.

An important point in determining further the product scope is to set the limit between a) the office imaging equipment devices which are used typically in work or private environments and b) the imaging equipment devices which are designed to address special commercial or professional needs. In the latter category the devices are very large in volume and their market sales are considered lower than in case of a). Based on manufacturers' input this delimitation was made using technical specifications i.e. maximum speed (ipm). A delimitation of the scope based on the marking technology used was not considered relevant.

[7] "Technical Background Report- Development of EU Ecolabel and GPP Criteria for Imaging Equipment", Institute for Prospective Technological Studies/ Joint Research Centre, March 2011

The definition of the imaging equipment devices and the scope of the Ecolabel criteria is as follows:

The product group “Imaging equipment” shall comprise products which are used in the office (private or professional) and their function is:

i) to produce a printed image (paper document or photo) through a marking process either from a digital image (provided by a network/card interface) or from a hardcopy through a scanning/copying process or/and

ii) to produce a digital image from a hard copy through a scanning/copying process.

The Ecolabel criteria apply to products which are marketed as printers, copiers and multifunctional devices (MFD). Other types of imaging equipment devices i.e. fax machines, digital duplicators, mailing machines and scanners are excluded from the scope. The following marking technologies can be used: Electrophotography (EP), Ink Jet (IJ), Solid Ink (SI), Direct Thermal (DT), Dye Sublimation (DS), Impact, High Performance IJ, Stencil and Thermal Transfer (TT).

The following large products which are not typically used in household and office equipment with the following technical specifications are also excluded from the scope of this decision:

- standard BW format products with maximum speed over 66 A4 images per minute;
- standard colour format products with maximum speed over 51 A4 images per minute;

(speed to be rounded to the nearest integer in the same way as prescribed in the ENERGY STAR agreement).

A "*printer*" is a commercially available imaging product that serves as a hard copy output device, and is capable of receiving information from single-user or networked computers, or other input devices (e.g., digital cameras). The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as printers, including printers that can be upgraded into MFDs in the field.

A "*copier*" is a commercially available imaging product whose sole function is the production of hard copy duplicates from graphic hard copy originals. The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as copiers or upgradeable digital copiers.

A "*multifunction device (MFD)*" is a commercially available imaging product which is a physically integrated device or a combination of functionally integrated components that performs two or more of the core functions of copying, printing, scanning, or faxing. The copy functionality as addressed in this definition is considered to be distinct from single sheet convenience copying offered by fax machines. The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as MFDs or multifunction products (MFPs).

3 ECOLABEL CRITERIA

The following criteria are proposed for the EU Ecolabel for imaging equipment. The criteria are classified in the following areas:

1. Paper Management
2. Energy efficiency
3. Indoor air emissions
4. Noise
5. Substances and mixtures in imaging equipment
6. Reuse, recycling and end-of-life management
7. Ink and toner consumables
8. Corporate criteria
9. Social criteria

The above list covers key environmental areas as indentified by IPTS and agreed to by the stakeholders in the 1st AHWG meeting (points 1 to 7). Complementary corporate criteria were added to these areas (i.e. user information, information appearing next to the Ecolabel flower logo).

3.1 Paper management

3.1.1 Formulation and verification of paper management criteria

The following three criteria fall under the category of paper management. Their proposed formulation and verification are given below.

3.1.1.1 Criterion 1 - Availability of N-up printing

The following formulation is proposed:

Imaging equipment devices shall offer as a standard feature the capability to print and/or copy several pages of a document on one sheet of paper when the product is managed by original software provided by the manufacturer (printer driver).

Assessment and verification

The following assessment and verification is proposed:

The applicant shall provide to the awarding competent body a declaration of compliance with these requirements.

3.1.1.2 Criterion 2 - Duplex printing requirement

The following formulation is proposed:
Imaging equipment devices with a maximum operating speed for monochrome printing/copying of 25 ipm (images per minute) or more for A4 size paper shall be equipped with an automatic double-side print/copy unit (a duplex-unit).

The duplex printing and/or copying function shall be set as default in the original software provided by the manufacturer and the following information (warning) shall be displayed to the user product when the default setting is changed into one-side printing: "This mode of printing will contribute to higher environmental impacts than double-side printing".

Assessment and verification
The applicant shall provide to the awarding competent body a declaration of compliance with these requirements.

3.1.1.3 Criterion 3 - Use of recycled paper

The following formulation is proposed:
Imaging equipment devices must be capable of processing recycled paper made of 100% post-consumer paper that meets the requirements of EN 12281:2002. The applicant shall be free to recommend certain types of recycled paper.

Assessment and verification
The applicant shall provide to the awarding competent body a declaration of compliance with these requirements.

3.1.2 Rationale of paper management criteria (criteria 1-3)

The most significant aspect affecting the overall life cycle environmental performance of the product group of imaging equipment is the consumption of paper.

The environmental assessment, conducted in the framework of the study, shows (as explained in detail in the 1st Working Document[8]) that paper consumption, followed by energy consumption in the use phase, has the most dominant role in the life cycle of imaging equipment influencing the overall environmental product performance. The high importance of paper consumption is related to the large energy demand in the paper production phase.

Indicatively, in a base-case assessment for monochrome MFD-copier used in a working environment, as analysed in the Preparatory Study for LOT 4[9], the consumption of paper was assumed to be 87 880 pages for each of the six years of the product's lifetime. The total energy consumption of the stock of copiers, printers and MFDs, as modelled in this study, shows that for the reference year 2005 the consumption of paper was responsible for 80 % (or 586 PJ) of the total EU energy consumption related to the life cycle of imaging equipment. This very high contribution of the paper use to the overall energy consumption affects notably other environmental impact categories, as significant environmental impacts are related to the energy production phase. This indicates the strong need for efficient use of paper for a reduction in its total consumption.

Following the discussion and conclusions from the stakeholders' consultation conducted in the framework of the criteria development process, the rationales for the proposed criteria on paper management are presented.

3.1.2.1 Rationale of Criterion 1 - Availability of N-up printing

This criterion is set to ensure that the user has the possibility to print more than one digital page on the same side of one paper sheet. This function is user friendly and is considered to reduce unnecessary paper consumption. This requirement is included in the industry voluntary agreement with regard to the EU Ecodesign Directive 2005/32/EC for energy using products.

3.1.2.2 Rationale of Criterion 2 - Duplex printing requirement

[8] Jiannis Kougoulis, Oliver Wolf "Working Document Input to 1st AHWG on 21st March 2011", Institute for Prospective Technological Studies/ Joint Research Centre, March 2011
[9] DG TREN Preparatory Studies for Eco-Design Requirements of EuPs. LOT 4. 'Imaging Equipment'. Final Report. http://www.ecoimaging.org/doc/Lot4_T1_Final_Report_2007-11-12.pdf

This requirement is found in all Ecolabel schemes investigated, including the MS Ecolabels. The requirements on duplex printing are also included in the Energy Star label. The duplex printing function is considered to be very effective for the reduction of paper consumption, especially when it is set as a default mode. The threshold, of 25 ipm is derived from stakeholders' input.

3.1.2.3 Rationale of Criterion 3 - Use of recycled paper

This requirement is currently used in the MS Ecolabel schemes and was agreed in the 1st AHWG Meeting. It is considered important that Ecolabel products contribute to promotion of recycling and facilitate use of recycled products.

3.2 Energy efficiency

3.2.1 Formulation and verification of criteria on energy efficiency

3.2.1.1 Criterion 4 - Energy efficiency

The following formulation is proposed:

The energy consumption of the product shall fulfil the energy requirements of Energy Star v.2.0 criteria for imaging equipment. If a newer version of Energy Star v2.0 for imaging equipment is published, then the product shall comply with the energy efficiency requirements of this version.

Assessment and verification

The applicant shall provide to the awarding competent body a declaration of compliance with the requirements as set in Energy Star v2.0 or if applicable of the latest published version of Energy Star requirements for imaging equipment and a test report with the results of the energy efficiency test according to the methods specified in Energy Star. Energy Star v.2.0 (or if applicable of a newer published version) labelled products are deemed to comply with the requirements of this criterion and the applicant shall submit a copy of the energy label award.

3.2.2 Rationale of Criterion 4 - Energy efficiency

After paper consumption, the next most important aspect regarding the life cycle environmental performance of imaging equipment is energy consumption in the use phase. This outcome is confirmed from several LCA studies, as presented in the Working document for the 1st AHWG. It is estimated that energy consumption in the use phase can account for approximately 2/3 of the total energy consumption of imaging equipment during product lifetime (energy consumption related to paper use is not considered). Thus, a better environmental performance can be achieved by energy efficient products. The consumption of less energy is also beneficial with respect to other investigated environmental aspects due to the lower pollutant emissions in the energy production phase.

The electricity consumption in the use phase is an aspect which is dependent on the product design (different from the previous case, i.e. paper consumption, which is strongly user dependent) and together with the energy label criteria is also a key aspect for the EU Ecolabel criteria. Energy efficiency is also one of the main environmental goals set by the manufacturers. The development of the electronic sector is vast especially and the trend of producing more energy efficient products is very high.

With regard to energy efficiency, as discussed in the 1st AHWG meeting, requirements in the new version of the Energy Star v2.0 for imaging equipment are proposed. Energy Star is considered the most successful energy label with a high number of applications and it is also the EU Energy label for the product group of imaging equipment. Revision of the Energy Star label is planned to take place every 2 years due to its vast developments in the IT and EEE sector.

As energy efficiency plays an important role in the overall environmental performance of the product, additional consultation was undertaken with the stakeholders and a sub-AHWG on energy was formed. In the discussions which took place within this group the following issues were addressed:

a) New developments and changes of Energy Star 1.1 criteria for imaging equipment;

b) A proposal made by IPTS to use as indication for the EU Ecolabel energy efficiency requirements calculation based on the industry voluntary agreement and Energy Star 1.1;

c) Harmonisation possibilities with the energy label of Energy Star;

d) The option of having a dynamic link with the Energy Star label and proposed compliance with Energy Star 2.0 and if available with the latest version of Energy Star for imaging equipment.

With regard to point a) the sub-group proposed (as agreed in the 1st AHWG meeting) to align the energy efficiency requirements with Energy Star 2.0 criteria developments and found that the changes introduced in the revision contribute to improving the measurement of the energy efficiency of the imaging devices. Based on the current stand point a first draft version of the Energy Star 2.0 is planned to be released by the end of October. Stakeholders will be asked for comments and a final version of the Energy Star requirements will be released 3 months later (at the beginning of February 2012). The criteria will enter into force 9 months later – by the end of 2012. Thus, the revision process of Energy Star 2.0 criteria goes in parallel to the development of the EU Ecolabel criteria for the imaging equipment. The latest documents regarding the Energy Star revision are given in Annex 6.2.

With regard to point b) a proposal related to energy efficiency calculation for EU Ecolabel (based on the "industry voluntary agreement"[10] and the Energy Star 1.1.) is given in Annex 6.2. The sub-group agreed with this approach and proposed to forward this feedback to the Energy Star criteria developers. This was undertaken by the IPTS.

It is considered that current criterion proposal facilitates the harmonisation with the EU Energy labelling scheme in this case with Energy Star label. Possibilities of common recognition and agreement with the US Energy Star should be further explored.

The option of having a dynamic link with the Energy Star label by formulating the criterion with inclusion of compliance not only to the Energy Star 2.0 requirements but to the latest Energy Star version for imaging equipment is supported by several stakeholders. It is considered that in that way compliance with the best performing products (in case the next Energy Star revision takes place earlier than the EU Ecolabel criteria revision) is ensured.

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[10] Industry Voluntary Agreement to improve the environmental performance of Imaging equipment placed on the European Market, Version 3.5, 15 February 2011 (this contributes to the objectives of Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products, in line with Recitals 18-20 and Annex VIII on self regulation)

However, as Energy Star criteria have already and are further planned to be expanded to areas which are not exclusively related to the energy efficiency in the use phase, e.g. duplex requirements, or life cycle impacts (for details see Annex 6.2), the EU Ecolabel criterion proposal asks for the compliance with only the energy efficiency requirements in the use phase of the latest Energy Star criteria version.

3.2.3 Discussion point – Verification of energy efficiency criterion

With the proposed formulation in Criterion 4, a 3rd party verification of the tested energy efficiency performance of the product is not required. Currently a self declaration of the manufacturer is sufficient for the European counterpart of Energy Star label, the EU Energy Star label. However, this is not the case for the US Energy Star labelled products for which the test results from an Energy Star Certification body are requested.

A 3rd party verification may have in general higher costs for the applicant. However 3rd party verification was proposed by many stakeholders and is a preferable option for the EU Ecolabel as stated in the "Guidelines for a procedure for checking the criteria in respect of applications: use of test laboratories. December 2008" submitted by the competent bodies[11]. Considering this, an alternative option for the assessment and verification is formulated as follows:

Alternative option of Assessment and verification for Criterion 4

> *The applicant shall provide to the awarding competent body a declaration of compliance with the requirements as set in Energy Star v2.0 or if applicable of the next version of Energy Star requirements for imaging equipment and a test report from an accredited laboratory containing the results of the energy efficiency test according to the methods specified in Energy Star version 2.0 or if applicable of the next version of Energy Star requirements for imaging equipment. The applicant shall attach a copy of the valid accreditation certificate of the test laboratory. Energy Star v.2.0 (or if applicable of a newer published version) labelled products for which the energy consumption has been measured by an Energy Star certification body are*

[11] Guidelines for a procedure for checking the criteria in respect of applications: use of test laboratories. Draft December 2008.
It is stated that " (…) Where possible, the testing should be performed by laboratories that meet the general requirements of EN ISO 17025 or equivalent"

deemed to comply with the requirements of this criterion and the applicant shall submit a copy of the energy label award.

Question to stakeholders: Please, comment if a 3rd party verification of the product's energy efficiency performance shall be required in the EU Ecolabel criteria.

3.3 Indoor emissions

3.3.1 Formulation and verification of criteria on indoor emissions

3.3.1.1 Criterion 5 - Restriction of TVOC, benzene, styrene, ozone and dust indoor emissions

The following formulation is proposed:

In the use phase the product shall not emit the below listed pollutants in amounts higher than the maximum emission rates given below:

Substance	Emission rate Print phase (mg/h)		Emission rate Ready phase (mg/h).	
	Colour Printing Total in ready + print phase	Monochrome printing Total in ready + print phase	Desktop products	Floor-mounted equipment (Volume >250 litres)
TVOC (total volatile organic compounds)	18	10	1	2
Benzene	<0.05	<0.05		
Styrene	1.8	1.0		
Ozone	3.0	1.5		
Dust	4.0	4.0		

All the above emission rates must be measured in accordance with the requirements described in ECMA-328 5th edition (based on Annex C9. Model for RAL-UZ 122 Option) or Blue Angel: RAL-UZ 122 Version June 2006.

Assessment and verification

The applicant shall submit to the competent body the results of the emission test according to the methods specified in ECMA-328 5th edition or RAL-UZ 122 version June 2006.

3.3.2 Rationale of criteria on indoor emissions (criterion 5)

Criterion 5 is mainly based on the respective criterion of Blue Angel, which was presented as an option in the 1st AHWG meeting. In the area of indoor emissions currently Nordic Swan as well as all other worldwide Ecolabel schemes in which are found criteria on this area uptake the developments of Blue Angel. This criterion was agreed in the 1st AHWG.

The use of the ECMA-328 standard measurement of the pollutants is proposed as this is the latest international standard. The proposed threshold values are the same as the one used in the current Blue Angel criteria thus its application is tested and was proved beneficial. Therefore it is also proposed for the EU Ecolabel.

3.4 Noise emissions

3.4.1 Formulation and verification of criteria on noise emissions area

The elaboration of Criterion 6 and the respective requirements regarding noise emissions of imaging equipment was a joint work between German Environmental Agency and IPTS. The modelling of noise emissions was based on data derived from Blue Angel labelled products.

3.4.1.1 Criterion 6 - Noise emissions

The following formulation is proposed:

The noise emission is rated by the declared A-weighted sound power level depending on printing speed per minute given in dB with one decimal place accuracy (or in B with two decimal places accuracy).

The declared A-weighted sound power level L_{WAd} of the product shall not exceed the following limits:

a. For monochrome printing – the A-weighted sound power level limit value $L_{WAd,lim,bw}$ shall be determined depending on the operating speed S_{bw} given with one decimal place accuracy according to the following formula:

$$L_{WAd,lim,bw} = 37 + 20*\log(S_{bw}+ 8)\ dB$$

$L_{WAd,lim,bw}$ = A-weighted sound power level limit for monochrome printouts given in dB

b. For colour printing on parallel systems – the A-weighted sound power level limit value $L_{WAd,lim,co}$ shall be determined depending on the operating speed S_{co} given with one decimal place accuracy according to the following formula:

$$L_{WAd,lim,co} = 38 + 20*\log(S_{co}+ 8)\ dB$$

$L_{WAd,lim,co}$ = -weighted sound power level limit in dB for colour printouts

c. In addition, for both monochrome and colour printing – the A-weighted sound power level limit value $L_{WAd,lim,co}$ shall not exceed an upper limit of 75.0 dB:

$$L_{WAd,lim,bw} < 75.0\ dB$$

$$L_{WAd,lim,co} < 75.0\ dB$$

For serial electrophotographic colour devices with $S_{co} \leq 0,5\ S_{bw}$ the sound power level shall be determined and indicated. For assessment purposes compliance with $L_{WAd,lim,bw}$ for monochrome printouts with printing speed S_{bw} shall be considered exclusively.

Assessment and verification

The applicant shall demonstrate compliance with the criteria requirements and submit the results of the A-weighted sound power according to the methods specified in ISO 7779 3rd edition (2010) (corresponds to ECMA-74:2010) as described in the noise measurement method section of the criteria background report[12]. The measured values shall be filled in and confirmed by the testing laboratory on the basis of the test report. The testing laboratory must be accredited according to DIN EN ISO/IEC 17025 as well as according to ISO 7779 for acoustic measurements. The test laboratory shall attach a copy of the valid accreditation certificates.

[12] See Annex 6.4

3.4.2 Rationale of Criterion 6 on noise emissions

The noise emission Criterion 6 is in line with the recent developments undertaken in Blue Angel scheme, which is one of the leading worldwide in the area of noise criteria for Ecolabels. Nordic Swan as well as other third country Ecolabel schemes usually overtake the noise criteria and benchmarks proposed by the Blue Angel. In the 1st AHWG meeting the group agreed to base the criteria related to noise exposure on the criteria set in the Blue Angel scheme. In comparison to the current available version of Blue Angel (Ed. May 2009), which is valid until the end of 2011, the following amendments are proposed for the EU Ecolabel:

- New formula for determining the noise limits based on logarithmic models;
- Testing method based only on ECMA-74;
- Update and alignment with ISO 7779 (3rd edition 2010);
- Change of paper sheet weight from 60 to 80 g/m² in testing.

The main change is the proposal of modelling using the logarithmic models. This was the outcome of investigations on noise emission values of MS Ecolabelled products. The main conclusions on the investigations on the modelling curve are presented below.

The A-weighted sound power level LWAd of imaging equipment in relation to the operating speed Sbw for monochrome printing is shown on The data was obtained from the database of Ecolabelled products of Blue Angel.

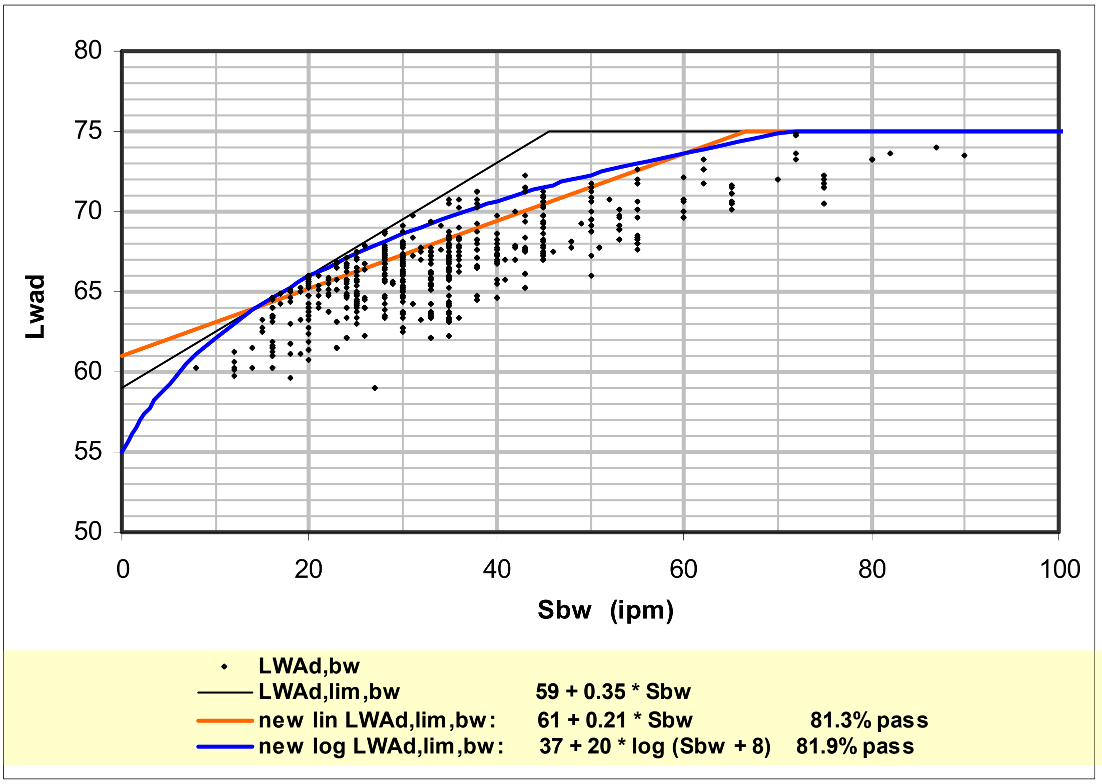

Figure 1 A-weighted sound power level LWAd of imaging equipment in relation to the operating speed Sbw for monochrome printing. Data basis Ecolabelled products of Blue Angel

In Figure 1 three possible modelling curves are given:

the current linear limit curve (black line) with $L_{WAd,lim,bw}$ = 59 + 0.35 * S_{bw} dB

a logarithmic limit curve (blue line) with $L_{WAd,lim,bw}$ = 37 + 20*log(S_{bw}+ 8) dB

another linear model (orange line) with $L_{WAd,lim,bw}$ = 61 + 0.21 * S_{bw} dB

The first curve is the current limit curve ($L_{WAd,lim,bw}$ = 59 + 0.35 * S_{bw} dB). This linear limit curve goes back to 2003 when it was first introduced for Blue Angel products. Since then development and improvements have been made and currently an update of the threshold in order to promote the best products is considered of relevance.

However, the current data availability is limited to data sets from the currently Ecolabelled products. Thus, this data is considered to reflect the best performing products and not an average sample of all the products found in the market. This complicates the determination of a new limit curve.

In order to overcome this obstacle, the percentage of products which will pass if a new limit curve is applied is calculated. This percentage is indicated in Figure 1 and in case of the logarithmic curve b) it is 81.9%, while in case of the linear curve c) it is 81.3 %. In general for the current needs of the EU Ecolabel and based on the available data it is considered important to model the limit curve in a way that will better reflect the modeling sample but also allow a high number of the Ecolabelled products to reach these limits.

Based on the above graph (Figure 1) it can be identified that the logarithmic curve (i.e. the curve b) better reflects the modeling relation between the A-weighted sound power level L_{WAd} of the product and its performance speed S_{bw} in ipm. Moreover, there are a few more products which pass this limit than in the case of c) – the linear modelling curve option, as the pass rate is 81.9 versus 81.3 % respectively.

The majority of products which are beyond the limits of the logarithmic curve have speeds in the range of 28 -38 ipm. In this range of speed there are relatively many products and, based on the available data, not only the frontrunners but also an average Ecolabelled product performs much better, has lower $\boldsymbol{L_{WAd}}$ (i.e. for S_{bw} =35 ipm the average is 65.09dB whereas the limit is 69.67dB). Conclusively, it is proposed to use the logarithmic modelling curve b) expressed with the formula: $L_{WAd,lim,bw} = 37 + 20*\log(S_{bw}+ 8)$ dB as it more accurately reflects the modeling relation between A-weighted sound power level of the product and operational speed.

Similar investigations were undertaken for the case of colour printing. In the A-weighted sound power level L_{WAd} of imaging equipment in relation to the operating speed S_{bw} for colour printing is given. The data basis is the one of Blue Angel.

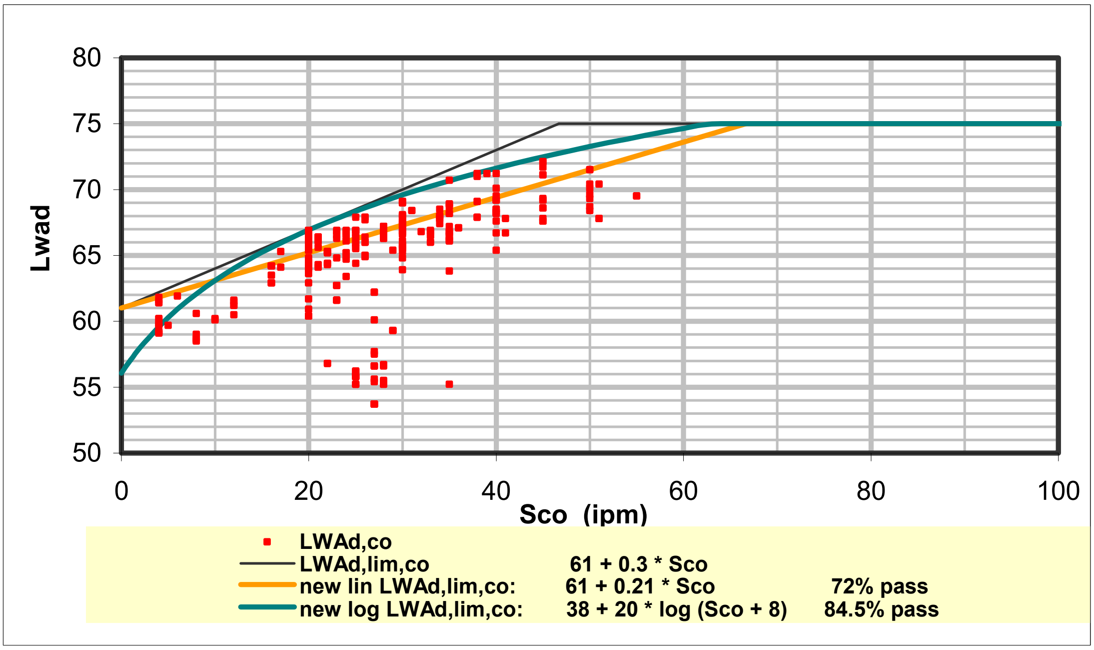

Figure 2 A-weighted sound power level L_{WAd} of imaging equipment in relation to the operating speed S_{bw} for monochrome printing. Data basis Ecolabelled products of Blue Angel

Similar to the case of monochrome printing three possible modelling curves are given in Figure 2:

the current linear limit curve (black line) with $L_{WAd,lim,co}$ = 61 + 0.30 * S_{co}dB

a logarithmic limit curve (green line) with $L_{WAd,lim,co}$ = 38 + 20*log(S_{co}+ 8) dB

another linear model (orange line) with $L_{WAd,lim,co}$ = 61 + 0.21 * S_{co} dB

Again, also for colour printing we can identify that the logarithmic modelling curve b) expressed with the formula: $L_{WAd,lim,bw}$ = 38 + 20*log(S_{bw}+ 8) dB better reflects the modelling relation between A-weighted sound power level of the product and operational speed S_{co}.

The proposed logarithmic modeling formula for setting the thresholds for the colour printing can also be derived from the respective one of monochrome printing:

$$L_{WAd,lim,co} = L_{WAd,lim,bw} + 1 \text{ dB}$$

The addition of 1 dB for the colour printing seems reasonable as colour printing reaches, on average, higher weighted sound power levels than the monochrome one. For colour printing it shall be highlighted that the majority of products which cannot match the thresholds based on the proposed logarithmic limit curve are with the speed of 10 ipm or lower. Imaging equipment of that low speed is typically not used in an office working environment.

Moreover, the maximum limit of 75.0 dB for both monochrome and colour printing was overtaken from the current Member State ecolabeling criteria.

More detailed information with regard the noise emissions Criterion 6 and other discussion points on the area of noise emissions are presented in Annex 6.4.

3.5 Substances and mixtures in imaging equipment

3.5.1 Formulation and verification of criteria on the area substances and mixtures in imaging equipment

The following criteria fall under the category of substances and mixtures in imaging equipment. Their proposed formulation and verification are given below. These criteria were jointly developed and elaborated with the external[13] technical experts Stefan Posner and Roland Weber.

3.5.1.1 Criterion 7 - Hazardous substances and mixtures

The following formulation is proposed:

In accordance with Article 6(6) of Regulation (EC) No 66/2010, the product or any article of it shall not contain substances referred to in Article 57 of Regulation (EC) No 1907/2006 nor substances or mixtures meeting the criteria for classification in the following hazard classes or categories in accordance with Regulation (EC) No 1272/2008 of the European Parliament and of the Council (14).

List of hazard statements and risk phrases:

Hazard statement ([15])	Risk Phrase ([16])
H300 Fatal if swallowed	R28
H301 Toxic if swallowed	R25
H304 May be fatal if swallowed and enters airways	R65
H310 Fatal in contact with skin	R27
H311 Toxic in contact with skin	R24
H330 Fatal if inhaled	R23/26
H331 Toxic if inhaled	R23
H340 May cause genetic defects	R46
H341 Suspected of causing genetic defects	R68
H350 May cause cancer	R45
H350i May cause cancer by inhalation	R49
H351 Suspected of causing cancer	R40

[13] Stefan Posner, Swerea IVF AB, Besöksadress: Argongatan 30, 431 53 Mölndal, Sweden
Roland Weber, POPs Environmental Consulting, D-73035 Göppingen, Germany
([14]) OJ L 353, 31.12.2008, p. 1.
([15]) As provided for in Regulation (EC) No 1272/2008.
([16])As provided for in Council Directive 67/548/EEC (OJ 196, 16.8.1967, p. 1).

H360F May damage fertility	R60
H360D May damage the unborn child	R61
H360FD May damage fertility. May damage the unborn child	R60/61/60-61
H360Fd May damage fertility. Suspected of damaging the unborn child	R60/63
H360Df May damage the unborn child. Suspected of damaging fertility	R61/62
H361f Suspected of damaging fertility	R62
H361d Suspected of damaging the unborn child	R63
H361fd May damage fertility. May damage the unborn child	R62-63
H362 May cause harm to breast fed children	R64
H370 Causes damage to organs	R39/23/24/25/26/27/28
H371 May cause damage to organs	R68/20/21/22
H372 Causes damage to organs	R48/25/24/23
H373 May cause damage to organs	R48/20/21/22
H400 Very toxic to aquatic life	R50/50-53
H410 Very toxic to aquatic life with long-lasting effects	R50-53
H411 Toxic to aquatic life with long-lasting effects	R51-53
H412 Harmful to aquatic life with long-lasting effects	R52-53
H413 May cause long-lasting effects to aquatic life	R53
EUH059 Hazardous to the ozone layer	R59
EUH029 Contact with water liberates toxic gas	R29
EUH031 Contact with acids liberates toxic gas	R31
EUH032 Contact with acids liberates very toxic gas	R32
EUH070 Toxic by eye contact	R39-41

The use of substances or mixtures in the final product which upon processing change their properties in a way that the identified hazard no longer applies is exempted from the above requirement.

Concentration limits for substances or mixtures meeting the criterion for classification in the hazard classes or categories listed in the table above, and for substances meeting the criterion of Article 57 (a), (b) or (c) of Regulation (EC) No 1907/2006, shall not exceed the generic or specific concentration limits determined in accordance with the Article 10 of Regulation(EC) No1272/2008. Where specific concentration limits are determined, they shall prevail against the generic ones.

Concentration limits for substances meeting criteria of Article 57 (d), (e) or (f) of Regulation (EC) No 1907/2006 shall not exceed 0.1 % weight by weight.

The following substances/uses of substances are specifically derogated from this requirement:

Articles with weight below 10 g	All hazard statements and risk phrases
Homogeneous parts of complex articles with weight below 10 g	All hazard statements and risk phrases
Inks and toners and cartridges	All hazard statements and risk phrases
Ni in stainless steel of all types other than of high-sulphur grades (S > 0.1%)	
2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol CAS 3147-75-9	
Triphenylphosphine CAS 603-35-0	

Assessment and verification

For each article and/or homogeneous part of complex articles with weight over 10 g the applicant shall provide a declaration of compliance with this criterion, together with related documentation, such as declarations of compliance signed by the suppliers of substances and copies of relevant Safety Data Sheets in accordance with Annex II to Regulation (EC) No 1907/2006 for substances or mixtures. Concentration limits shall be specified in the Safety Data Sheets in accordance with Article 31 of Regulation (EC) No 1907/2006 for substances and mixtures.

3.5.1.2 Criterion 8 - Substances listed in accordance with article 59(1) of Regulation (EC) No 1907/2006

The following formulation is proposed:

No derogation from the exclusion in Article 6(6) shall be given concerning substances identified as substances of very high concern and included in the list foreseen in Article 59 of Regulation (EC) No 1907/2006, present in mixtures, in an article or in any homogenous part of a complex article in concentrations higher than 0.1% w/w. Specific concentration limits determined in accordance with Article 10 of Regulation (EC) No1272/2008 shall apply in case it is lower than 0.1% w/w.

Assessment and verification:

The list of substances identified as substances of very high concern and included in the candidate list in accordance with Article 59 of Regulation (EC) No 1907/2006 can be found here:

http://echa.europa.eu/chem_data/authorisation_process/candidate_list_table_en.asp

Reference to the list shall be made on the date of application.

The applicant shall provide a declaration of compliance with this criterion, together with related documentation, such as declarations of compliance signed by the suppliers of substances and copies of relevant Safety Data Sheets in accordance with Annex II to Regulation (EC) No 1907/2006 for substances or mixtures. Concentration limits shall be specified in the Safety Data Sheets in accordance with Article 31 of Regulation (EC) No 1907/2006 for substances and mixtures.

3.5.1.3 Criterion 9 - Plastic parts

The following formulation is proposed:

a. If any plasticiser substance in the manufacturing process is applied, it must comply with the requirements on hazardous substances set out in Criterion 7 and Criterion 8.

   Additionally, the following phthalates: di-n-octyl phthalate (DNOP), di-isononyl phthalate (DINP), di-isodecyl phthalate (DIDP), Dibutyl phthalate (DBP) Bis (dibuthyl phtalate), DEHP (bis(2-ethylhexyl) phthalate (DEHP), Benzylphtalate) BBP (benzyl butyl phthalate (BBP), phtalate), SCCP (short chain chlorinated paraffins (SCCP), Diisobutyl phthalate (DIBP (diisobutyl phtalate) shall not intentionally be added to the product.

b. Tetrabromobisphenol-A (TBBPA) shall not intentionally be used in the production process of the plastic parts.

c. Plastic parts of articles or homogeneous parts of complex articles with weight 25 g or more shall not contain a chlorine content greater than 50 % by weight.

d. Only biocidal products containing biocidal active substances included in Annex IA to Directive 98/8/EC of the European Parliament and of the Council and authorised for use in imaging equipment, shall be allowed for use. All biocides used shall be clearly indicated.

e. The product shall not contain brominated aromatic substances used as flame retardants. This restriction is not applicable for product articles of weight lower than 25 g and for homogeneous parts of complex articles of weight lower than 25 g with the following exceptions:

- chlorine and bromine-based polymers,
- plastic parts which contain PBBs (polybrominated biphenyls), PBDEs (polybrominated diphenyl ethers) or chlorinated paraffins.

Assessment and verification:

The applicant shall provide a declaration of compliance with this criterion, together with related documentation, such as declarations of compliance signed by the suppliers of substances and copies of relevant Safety Data Sheets. The applicant shall provide information on the plasticisers used in the product. The applicant shall provide information on the maximum chlorine content of the plastic parts. A declaration of compliance signed by the plastic and biocides suppliers and copies of relevant safety data sheets about materials and substances shall also be provided to the awarding competent body. The applicant shall provide information on the intentionally added substances used as flame retardants.

3.5.1.4 Criterion 10 - Mercury in fluorescent lamps

The following formulation is proposed:

Mercury or its compounds shall not intentionally be added to the backlights used in imaging equipment.

Assessment and verification:

The applicant shall declare to the competent body that the backlights of the product do not contain more than 0.1 mg of mercury or its compounds per lamp. The applicant shall also provide a brief description of the lighting system used.

3.5.2 Rationale of criteria related to hazardous substances (criteria 7-8)

Ecolabel Regulation 66/2010 demands that in the process of determination of the Ecolabel criteria the substitution of hazardous substances with safer ones shall be considered. This substitution can be as such or via the use of alternative materials or designs, wherever it is technically feasible and together with the potential to reduce environmental impacts due to durability and reusability of products.

In particular, the Article 6(6) of the EU Ecolabel Regulation 66/2010 states explicitly that "the EU Ecolabel may not be awarded to goods containing substances or preparations/mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with Regulation (EC) No 1272/2008 on classification labelling and packaging of substances and mixtures nor to goods containing substances referred to in Article 57 of Regulation (EC) No 1907/2006 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)".

Within EU Ecolabel the criterion area regarding hazardous substances and mixtures is considered a horizontal issue, which is applicable for numerous product groups. The above presented list of H- and R-phrases is the outcome of the investigation carried out by DG ENV and DG ENTR in which the described text of the Ecolabel Regulation is expressed in more technical and easier to apply terms. This H- and R- phases list has also been applied in other EU Ecolabel criteria for similar electronic products, e.g. for PCs([17]) and notebook computers([18]).

3.5.2.1 Threshold values for articles and related assessment and verification procedure

According to Article 3.3 of REACH an 'article' is defined as "an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition".

([17]) Official Journal of the European Union, Commission Decision of 6 June 2011 on establishing the ecological criteria for the award of the EU Ecolabel for notebook computers, available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:151:0005:0014:EN:PDF.
([18]) Official Journal of the European Union, Commission Decision of 6 June 2011 on establishing the ecological criteria for the award of the EU Ecolabel for notebook computers, available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:148:0005:0012:EN:PDF.

According to Directive 2011/65/EC (RoHS)([19]) a 'homogeneous material' is a "material of uniform composition or a material consisting of a combination of materials that cannot be disjointed or separated into different materials by mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes."

Concentration limits for substances meeting criteria of Article 57 (d), (e) or (f) of Regulation (EC) No 1907/2006 shall not exceed 0.1 % weight by weight (w/w). In this proposal two main issues for discussion with stakeholders have been identified:

- The threshold of 10 g given for articles and/or homogeneous parts of complex article;
- Self-declaration by the applicant to prove the compliance with these criteria.

In general it is suggested that the criteria fulfil the following:

a. be feasible for both the applicant and the competent bodies with regard to compliance verification procedure and have manageable administrative effort, and
b. have a high ambition level and allow to identify the environmental frontrunners by promoting the manufacturers who do not use substances of health risks and environmental concern.

In the past, for Ecolabel criteria applied to several similar product groups, a threshold of 25 g was used. The choice of this value is related to the fact that articles weighing 25 g or more can be traced back easily as they must be documented in Safety Data Sheets. This makes the inventory of substances in these articles quite straightforward.

Stakeholders suggest in the case of imaging equipment plastic parts weighting over 25 g cover app. 85 % of the total plastic parts of the product. Further, there is no significant difference among small, medium and high performance products.

However, the health and environmental risks are still considered significant in articles which weigh below 25 g if they contain substances characterized as carcinogenic, mutagenic or dangerous for reproduction (CMR). Therefore, efforts were made to address this issue and in

([19]) Directive 2011/65/EU of the European Parliament and f the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:174:0088:0110:EN:PDF.

similar electronic products, i.e. in the EU Ecolabel for personal computer and laptops, the respective value was reduced to 10 g.

Considering that in imaging equipment the number of articles weighing in the range of 10 g to 25 g is lower than in the case of computers or laptops, it seems feasible to apply this limit in this product group. Additionally, using the same threshold ensures coherence among Ecolabel criteria of electronic products.

It is suggested that the same limit of 10 g shall be applied to homogeneous parts of bigger and complex articles. As defined in REACH, the 'article' is determined based on functionality regardless of its weight, volume or number of different homogeneous parts. However, in a complex article it is possible to indentify homogeneous parts of variable weight (i.e. more than 10 or 25 g). Therefore in order to ensure consistency it is suggested to apply the same threshold limits to these items.

Based on manufacturers' feedback, concerns have been raised regarding the applicability of this criterion. One of the points of concern is the currently limited data availability. The proposed criterion is a generic criterion addressing in principle all substances, including additives, in all materials used in the final product. This is rather a new approach in the Ecolabel, which in the past had criteria related to substance restrictions for certain plastic parts or for certain substance groups or single compounds, e.g. flame retardants. This development, although considered an improvement towards fostering green manufacturing and eco-innovation, seems to entail difficulties for the applicants and their suppliers related to data collection. Thus, increased administrative burdens can be expected.

Another issue is the proposal of self-declaration of compliance by manufacturers. The self-declaration could reduce additional administrative burdens. However, stakeholders raise concerns about its effectiveness. The reason for this is related to the fact that the self-declaration currently refers only to what can be confirmed based on the current knowledge. Consequently, verification is lacking that the necessary underlying standard OECD tests for each R/H phrase have indeed been performed to ensure that the individual R/H phrases have not been assigned to the substance. The Safety Data Sheets for substances in articles contain only information about performed tests but do not reveal the data gaps. Therefore, there is a risk that substances with major data gaps could be approved and considered

’greener,’ but in fact could have higher health and environmental impacts than their better investigated substitutes.

Furthermore, if the OECD tests are conducted, this would lead to an increase in costs as well as a greater amount of animal testing needed. The latter shall be avoided based on Article 6(3) point (g) of the Ecolabel Regulation 66/2010 in which it is stated that "as far as possible the principle of reducing animal testing" shall be applied.

Summarising, it seems that proposing Criterion 7 and Criterion 8 is a step forward towards sustainability; nevertheless the aforementioned complications regarding lack of information, lack of testing and issues of practicability regarding the raised administrative burdens need to be taken into consideration. Such kind of burdens may hamper the uptake of the EU Ecolabel by manufacturers. In this respect stakeholders are asked to provide their feedback and comments on how to overcome these difficulties.

Questions to stakeholders:

Please, suggest operational solutions how to make the formulation of the assessment and verification method for Criterion 7 and Criterion 8 more effective.

3.5.2.2 Exemption of inks and toners

Inks, toners and cartridges are regarded as typical consumables of imaging equipment. These are separate products. Typically ink and toners cartridges are purchased by the user (with the exception of the first cartridge supplied together with the product when it is sold). Thus, in general, the effectiveness of criteria on consumables is considered limited.

Criteria related to the use of substances in these items are proposed separately, For inks and toners Criterion 15. This criterion covera the main environmental aspects related to these consumables. The application of Criterion 7 to ink and toners is considered to be related with a high administrative burden as the number of substances used in these items is considered to be very high and knowledge on them is not available and low effectiveness as these items are sold separately and their purchase is mainly decided by the user. The composition of inks is not always available and rights related to patents could also hamper the substance inventory. However, in the case of developing EU Ecolabel criteria for the product group of inks and toners such a type of criterion could be considered.

Questions to stakeholders:

Stakeholders are asked to comment if inks, toners and cartridges shall be derogated in the proposed Criterion 7.

3.5.2.3 Substances changing their properties during processing

In the EU Ecolabel criteria for PC as well in the one of notebooks in the respective Ecolabel criterion regarding the use of Hazardous substances and mixtures is stated that: " …The use of substances or mixtures which change their properties upon processing (e.g. become no longer bioavailable, undergo chemical modification) so that the identified hazard no longer applies is exempted from the above requirement".

During the stakeholders consultation process concerns were expressed regarding the use of the term "bioavailable". In order to avoid possible confusion on this thematic in the current Criterion 7 there is no reference given to bioavailability. Nonetheless, as requested by stakeholders, information about this aspect is provided below.

The following definition of bioavailability, as used in the Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP), could be used:

> "Bioavailability is the rate and extent to which a substance can be taken up by an organism and is available for metabolism or interaction with biologically significant receptors. Bioavailability (biological availability) involves both release from a medium (if present) and absorption by an organism (IPCS 2004)([20])."

However, it should be highlighted that bioavailability is not explicitly evaluated in hazard classification. It is important to keep in mind that the observation of systemic toxicity implicitly demonstrates a degree of bioavailability. When no toxicity is demonstrated in a test, this may be a result of either lack of intrinsic toxicity of the substance or lack of bioavailability in the test system employed.

20 European chemical Agency, "Guidance on the Application of the CLP Criteria", available online at: http://guidance.echa.europa.eu/docs/guidance_document/clp_en.pdf, page 71.

Hence, the non-bioavailability of a substance is difficult to verify and evaluate. In line with REACH guidelines 20, when a supplier proposes derogation from hazard classification on the basis of bioavailability, adequate and robust data should be provided to support the conclusion of lack of bioavailability. This is difficult as it is possible that a substance is bioavailable by one route but not another (e.g. absorbed following inhalation but not absorbed through the skin). In such cases the lack of bioavailability may derogate the substance classification for the relevant route.

When considering the non-bioavailability of a mixture, the evaluation shall be based on data for all relevant ingredients of the mixture. Potential interaction of the ingredients that could influence the bioavailability of the mixture as such or one of its components shall be considered.

A non-bioavailable substance may however, react with the media and be transformed to soluble available forms. The rate and extent at which this process takes place can vary extensively between different substances and can constitute an important factor in determining the appropriate hazard category. More information is given in Annex 6.6.

Information on relative bioavailability (e.g. relative amounts of absorption) within a related group/category of chemicals can be of some use in classification. It is possible that consideration of bioavailability data in a semi-quantitative manner would lead to the classification for the same hazard class but in a different category, on the ground that the extent of bioavailability would be reflected in the relative potency.

Nevertheless, as indicated in Article 12 (b) of CLP, there may be cases where a specific evaluation of bioavailability is warranted. In general terms, for a substance or mixture to have an effect on a biological or environmental system, there must be some degree of bioavailability.

Therefore, a substance or mixture does not need to be classified when it can be shown by conclusive experimental data from internationally acceptable test methods, e.g. from Regulation (EC) No 440/2008 (REACH), that the substance or mixture is not biologically available (UN Global Harmonised System OECD "task force 1.3.2.4.5.1").

3.5.2.4 Derogation requests

3.5.2.4.1 Derogation requests - Overview and description of the decision approach

Methodological approach

In general, substances and mixtures which fall in the H- and R- phrase classification, as presented in Criterion 7, are investigated. In line with Articles 6(6) and 6(7) of the Ecolabel Regulation 66/2010, the stakeholders can submit for a substance a request for derogation from this criterion. According to Article 6(7) of Regulation No 66/2010 on the EU Ecolabel, no derogation from the exclusion in Article 6(6) shall be given concerning substances identified as substances of very high concern (SVHC) and included in the list foreseen in Article 59 of REACH, present in mixtures, in an article or in any homogenous part of a complex article in concentrations higher than 0.1 % (w/w). Specific concentration limits determined in accordance with Article 10 of CLP Regulation No1272/2008 shall apply in the case that it is lower than 0.1% (w/w).

The methodological approach regarding the investigation of the request of derogations is as follows.

For each substance the following information and data is gathered:

- General physical and chemical properties, functionality of the substance and of the materials in which it is used, and its overall mass or concentration found in the product.
- Health and direct environmental impacts

  In this phase scientific information reveals the importance of how the hazardous effects of the substance occur and what are the potential health impacts., Potential direct environmental impacts due to the substance are also investigated in this phase.
- Life cycle considerations and indirect environmental impacts related to the use of this substance are further investigated.

  This information indicates/reveals whether the use of the substance raises high environmental concerns along the life cycle of the product, e.g. in stages like production, raw material extraction, recycling, thermal recovery or disposal on a landfill.
- Potential substitutes

In this phase the potential substitutes of the substance are investigated. It is important to identify whether safer – from the health and environmental viewpoint – substances are available. In this phase it can be also considered whether alternative materials can be used, thus preventing the use of the investigated hazardous substance.

Based on the overall information gathered for the given substance and on the decisiveness of each input, it is determined whether a derogation shall be granted or not.

In this phase we shall highlight that the aforementioned approach in which these four elements of information are collected has to be adapted to the particular characteristics and case-specific conditions. Depending on what type of substance is investigated, one piece of information may be more significant than another. For example, the life cycle considerations and the indirect environmental impacts are more relevant in the case of chemical additives which are related to the formation of dioxins than the case of Ni in stainless steel for which less significant indirect environmental impacts could be identified in the production or recycling phases.

Another important aspect in this respect is the availability of information. When the investigation covers many features of one specific substance the availability of information cannot be taken for granted. Data gaps can be expected. The lack of data is especially important regarding the question of substitution.

The potential alternatives shall be evaluated in order to be indicated as substitutes and better options than the substance requested for derogation. However, this implies that a similar investigation of the potential substitutes (like for the substance of interest) shall be carried out, i.e. including information on health and direct impacts, indirect environmental impacts in a life cycle perspective and functionality of the substances. Furthermore, a detailed investigation on the substitutes should also contain economic and technical considerations in order to explore if recommendation of the substitute is feasible under current conditions. Nevertheless, an indication on the potential of the substitution, especially when this is accessible and known, is important and therefore it was included to the appropriate extent in this investigation.

In this process of development of EU Ecolabel criteria for imaging equipment the industry asked for the following substances to be derogated from Criterion 7:

1. (1-methylethylidene)di-4.1-phenylenetetraphenyl diphosphate (also named bisphenolA bis(biphenylphosphate) (BDP))
2. 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol
3. Triphenylphosphine
4. Nickel in Stainless Steel

In addition to the above listed substances, a derogation request for antimony trioxide was submitted to the DG ENV in a later stage. This request does not specifically refer to the development of EU Ecolabel criteria for imaging equipment but is addressed in general for all product groups for which EU Ecolabel criteria are developed. As this request came in the last phase of the development of the EU Ecolabel criteria for imaging equipment, the investigation of this derogation request is not presented in this analysis.

The following sections present the information collected in the frame of the study, together with external expertise received for the above listed substances requested to be derogated from the hazardous substances criterion. More details of this analysis are available in the previous released report: "Discussion on hazardous substances criterion. Investigation of request for derogation" available via the project website[21].

3.5.2.4.2 Derogation requests – Conclusions regarding derogation request[21]

Conclusions regarding derogation request of bisphenolA bis(biphenylphosphate) (BDP)

The assessment of bisphenolA bis(biphenylphosphate) is hampered by data gaps and contradictory data. Nevertheless, there is enough data that indicates persistency, bioaccumulation and toxicity, as well as endocrine toxic properties for BDP. There are references indicating that BDP is biologically transformed into bisphenolA, which is a known endocrine-disrupting substance.

[21] This work was conducted jointly with the following experts: Stefan Posner and Roland Weber http://susproc.jrc.ec.europa.eu/imaging-equipment/stakeholders.html

Non-halogenated flame retardants were identified as applicable to each specific material matrix, where BDP is solely feasible for polycarbonate and its blends. Thus, substitutes are available.

Conclusively, applying the precaution principle, it is suggested based on the hazardous properties of bisphenolA bis(biphenylphosphate) that it cannot be derogated from the Criterion 7 as requested by the industry.

Conclusions regarding derogation request of 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol

2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol is mainly used as UV stabilizer in polycarbonate, and polycarbonate blends with ABS, and/or SAN and/or PET that is used in external housing parts, internal mechanical parts and internal optical parts with maximum load to 0.4 % (w/w).

During the product's use phase it is not expected that 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol is emitted to the environment due to its very low volatility and low load in the imaging equipment.

Since 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol has very low water solubility and high bioaccumulation potential, the environmental impact of the substance is expected to be through particles. Due to the low load in housings and similar parts any potential emissions to the environment of this substance are negligible.

There is no information available regarding the lack of potential substitutes. Stakeholders are invited to provide input on this topic.

Based on the findings[21] it is suggested that 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol may be derogated from the Criterion 7 as requested by the industry.

Additional information regarding the lack of alternative stabilizers to 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3,-tetramethylbutyl)phenol could complement the current findings. Stakeholders are asked to add to the available information on this aspect.

Conclusions regarding derogation request for triphenylphosphine

Triphenylphosphine is added in external housing parts (e.g. control panel cover, front, back and side housing panel) with a maximum load of 0,25% (w/w). Triphenylphosphine does not meet the requirements of Criterion 7 since it is H413 classified.

During the product's use phase it is not expected that triphenylphosphine is emitted to the environment due to its very low volatility and low load in the imaging equipment devices. Since triphenylphosphine has very low water solubility and high bioaccumulation potential the environmental, the impact of the substance is expected to be through particles. Due to the low load in housings and similar parts, any potential emissions to the environment of this substance are negligible.

It is likely that triphenylphosphine could be emitted through plastic particles during recycling of external housing parts. If the housings are incinerated above 500°C then all triphenylphosphine is irreversibly eliminated.

There is no information available regarding potential substitutes. Therefore this issue shall be discussed in the 2nd AHWG meeting.

Based on the findings[21] it is suggested that triphenylphosphine may be derogated from the Criterion 7 as requested by the industry.

In accordance with the available knowledge the derogation seems substantiated as triphenylphosphine does not pose environmental and health risks if handled under controlled and normal foreseeable conditions.

Conclusions regarding derogation request for Nickel in stainless steel

In general, metallic stainless steel is likely to exert very low toxicity. Nickel in stainless steel has been regarded as safe for use in toys (Directive 2009/48/EC[22]).

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[22] Directive 2009/48/EC on the safety of toys, p. 3 section (21)

Nonetheless, certain stainless steels with a sulphur addition (for example, AISI 303) may release nickel. The actual threshold for the induction of nickel allergy is unknown. In the case of sulphurated stainless steels like AISI 303, the risk of skin sensitization after prolonged skin contact is higher.

Nickel embedded in the stainless steel and, if handled along the life cycle under foreseeable conditions (i.e. BAT conditions), it will most likely be not released to the environment.

Further, the available information does not demonstrate that there is any substitute available for nickel in stainless steel which could ensure comparable properties in the end-product and be less hazardous and have fewer environmental concerns.

In conclusion, based on the findings[21] it is suggested that Nickel in stainless steel may be derogated as requested by the industry. Considerations are only raised when nickel is used in stainless steel of high-sulphur grades (S > 0.1%).

3.5.3 Rationale of criteria related to plastics (criterion 9)

Ecolabel Regulation 66/2010 Article 6(3) indicates that the Ecolabel criteria shall be developed taking into consideration environmental impacts along the whole product life cycle as well as the possibility of substitution of hazardous substances by safer ones or via the use of alternative materials or designs.

Furthermore, the investigation of substitution of hazardous and environmentally relevant substances with environmentally safer ones is addressed in this section based on the provisions of Article 6(3) of the Regulation 66/2010, as described above.

Criterion 9 is mainly related to indirect environmental impacts in the product life cycle of imaging equipment which can be avoided if the use of certain substances is avoided. In Criterion 9 different points are addressed from a) to e) see also section 3.5.1.3. The reasoning for each one of them follows.

3.5.3.1 Rationale of Criterion 9 point a. related to plastics

Criterion 9 point a) is similar to the EU Ecolabel criteria for notebooks and computers. One way to capture the substances with high health and environmental risks is to investigate the classification of the substances in the presented H- and R- phases. The list of H- and R-phrases, as presented in Criterion 7, allows identification of these relevant substances.

Moreover, a number of used plasticisers are classified as substances of very high concern (SVHC) as foreseen in Article 59 of REACH and they are likely to be found in electrical and electronic equipment. These are given below together with the information in which plastic types are used and in which concentration.

- Dibutyl phthalate (DBP): 15% w/w used in flexible PVC,
- Bis (2-ethylhexyl) phthalate (DEHP): 30 - 45% w/w used in flexible PVC,
- Benzyl butyl phthalate (BBP): 30 - 45% w/w used in flexible PVC.

In addition, the following phthalates used as plasticisers are explicitly restricted in the EU Ecolabel for laptops:

- di-n-octyl phthalate (DNOP),
- Di-isononyl phthalate (DINP),
- Di-isodecyl phthalate (DIDP).

In the following Table 1 information about regulated phthalates is presented.

Table 1: Information about regulated phthalates

Substances	Abbreviation	N° CAS	REACH annex XIV	REACH candidate List (SVHC)	REACH annex XVII	Cosmetic Directive 76/768/EEC	Food contact Directive 2007/19/EC
Diisobutyl phtalate	DiBP	84-69-5		X			
Dibutyl phthalate	DBP	84-74-2	X	X	X	X	X
Bis(2-methoxyethyl) phtalate	DMEP	117-82-8				X	
Di-n-pentyl phthalate	DNPP	131-18-0				X	

Benyl butyl phthalate	BBP	85-68-7	X	X	X	X	X
Di(ethylhexyl) phtalate	DEHP	117-81-7	X	X	X	X	X
Di(n-octyl) phthalate	DNOP	117-84-0			X		
Diisononyl phthalate	DiNP	28553-12-0			X		
Diisodecyl phthalate	DiDP	26761-40-0			X		
1,2-benzenedicarboxylic acid, di C6-8 branched alkylesters C7 rich	DIHP	71888-89-6		X			
1,2-benzenedicarboxylic acid, di C7-11 branched and linear alkylesters	DHNUP	68515-42-4		X			
Di isopentyl phthalate	DIPP	605-50-5				X	

Furthermore, technically suitable alternatives of these substances are available and already used extensively at present. There are several families of plasticisers other than phthalates which pose less environmental and health concerns. Among them are:

- Adipates
- Sebacates
- Azelates
- Citrates
- Trimellitates
- Organic phosphates
- Polymeric plasticizers
- Epoxidized vegetabilic oils

As these substances raise health and/or environmental concerns and substitutes for them are available it is proposed that the EU Ecolabel excludes their use.

3.5.3.2 Rationale of Criterion 9 point b. related to plastics

Further, Criterion 9 point b. refers to the use of tetrabromobisphenol-A (TBBPA) during the production process of the plastic parts. TBBPA is a high volume chemical (with trade volume app. 5 850 ton/year). TBBPA is known and acknowledged as a cytotoxicant, immunotoxicant, and thyroid hormone agonist, which has the potential to disrupt estrogen signalling. TBBPA is classified in H410/R50-53 as very toxic to aquatic life with long-lasting effects. More information regarding the direct health and environmental concerns related to the inherent properties of TBBA are given in Annex 6.10.

TBBPA is an aromatic brominated organic compound. It is used primarily as a reactive intermediate in the manufacture of flame retarded epoxy and polycarbonate resins, such as printed wiring board laminates and encapsulation of electronic components, and it constitutes an integral part of the polymer. TBBPA may also be used as an additive flame retardant physically mixed into the polymer, for example in the manufacturing of acrylonitrile-butadiene-styrene resins (ABS) and phenolic resins. When TBBPA is applied as an additive flame retardant it is mainly used together with antimony trioxide, which is not the case when it is used as a reactive flame retardant.

When reactive TBBPA is applied in imaging equipment it undergoes a chemical modification to a brominated polymer and due to the modification the TBBPA itself is no longer present in the brominated epoxy resin. TBBPA is also used for the manufacture of derivatives TBBPA-dimethylether, TBBPA-dibromopropylether, TBBPA-bis(allylether), TBBPA-bis (2-hydroxyethyl ether), TBBPA-brominated epoxy oligomers and TBBPA-carbonate oligomers. Criterion 9 point b) refers to the use of TBBPA in plastics. TBBPA is also used in printed circuit boards on the laminates. The environmental concerns on related to this were investigated and are highlighted in a recent report of US EPA. However, as 80% of the printed circuit boards use TBBPA it is not considered for technically feasible for the short term in which the proposed Ecolabel criteria would be valid to apply Criterion 9 point b for printed circuit boards laminates. Imaging equipment in which printed circuit boards do not use TBBPA or its derivates can be considered as BAT products.

Environmental concerns related to the use of TBBPA are identified in the post-consumption phase of imaging equipment. Avoiding the occurrence of environmental impacts in the post-consumption phase of imaging equipment is the main reason for the proposal of Criterion 9 point b. As TBBPA is a high volume chemical, the environmental savings potential, by avoiding its associated environmental impacts, is considered sufficient.

Environmental impacts related to TBBPA could take place at the end of life of imaging equipment, (e.g. in recycling and thermal treatment) and are mainly associated with formation of brominated and brominated-chlorinated dioxins and difurans[23]. The risk of direct emission of TBBPA when no BAT conditions are applied in the processing is considered high. A key driver for the formation of PBDD/PBDF and PXDD/PXDF is the precursor quality of brominated aromatic compounds including e.g. the flame retardants PBDE, PBB, brominated phenols or TBBPA[24 25].

Regarding the use of TBBPA as an additive or a reactive flame retardant for end-products the EU Risk Assessment Report (RAR) of TBBPA[26] on human health concludes that no health effects of concern have been identified for TBBPA and that any risk to workers, consumers and humans exposed via the environment is not expected. In the manufacturing phase it is concluded that there is a need for measures for reducing the emission from compounding and conversion sites (i.e. production and manufacturing sites) where TBBPA is used.

Moreover, in the same report (EU RAR) is also concluded regarding the formation of dioxins that from the available information it is clear that polybrominated dibenzo-p-dioxins and dibenzofurans are formed in the pyrolysis experiments with tetrabromobisphenol-A and its derivatives. The main products formed appear to be the mono- to tribrominated congeners and the yield of these products is generally up to a few tens of mg/kg polymer. Tetrabrominated congeners are also formed in some experiments at lower levels, and higher brominated congeners are found only occasionally. The amounts of 2,3,7,8-substituted congeners formed are very low, frequently below the analytical limit of detection. Since many different test systems have been used, it is difficult to compare directly the results from one test system to the other. It is not possible to relate these findings directly to the likely behaviour of tetrabromobisphenol-A during actual fires or controlled incineration.

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[23] PBDD/PBDF – polybrominated dioxins and furans, PXDD/PXDF, polybrominated-chlorinated dioxins and difurans

[24] Ebert J, Bahadir M. (2003). Formation of PBDD/F from flame-retarded plastic materials under thermalstress. *Environ. Int.* 29, 711-716

[25] Weber R, Kuch B. (2003) Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated-chlorinated dibenzodioxins and dibenzofurans. *Environ. Int.* 29, 699-710.

[26] European Union Risk Assessment Report (RAR) of TBBPA, 4rth priority list, Vol63 Joint Research Centre European Chemicals Bureau http://esis.jrc.ec.europa.eu/doc/existing-chemicals/risk_assessment/REPORT/tbbpaHHreport402.pdf

Regarding the dioxin formation the main environmental impacts occur under uncontrolled incineration conditions and in countries without advanced emission control technology. For example they are more likely to occure in Asian and African countries where a considerable amount of used and obsolete EEE is shipped as it is reported in the "Study on Hazardous Substances in Electrical and Electronic Equipment, Not Regulated by the RoHS Directive" for DG ENV in 2008[27]. According to this report these aspects have not or only partly been taken into account in the EU RAR of TBBPA. Thus, this report concludes that on basis of these potential risks to the environment and human health TBBPA is considered a potential candidate for an inclusion in RoHS.

In the following Table 2 regulations and relevant actions i.e. EU RAR related to TBBPA are presented.

Table 2: Regulations and actions related to TBBPA[27]

TBBP-A is included in the OSPAR List of Chemicals for Priority Action (Update 2007).
Indirectly, the regulations on the design of municipal incinerators include provisions for TBBPA containing materials. Therein, a minimum incineration temperature of 850°C for 2 seconds is required (EEC 1989a and 1989b). A higher incineration temperature of 1,100°C is required for hazardous waste incinerators where waste containing more than 1% halogens is incinerated (EEC 1994). At high temperatures (e.g. around 800°C) only trace amounts of mainly mono- and dibrominated dibenzo-p-dioxins and dibenzofurans appear to be formed from TBBPA containing materials.
Some EU / national regulations cover the management of waste from electrical and electronic products or incineration in general • Directive 2002/96/EC (WEEE Directive) prescribes that plastics containing brominated flame retardants have to be removed from any separately collected WEEE and shall be disposed of or recovered in compliance with Article 4 of Council Directive 75/442/EEC. • In Denmark, flame-retarded plastic has to be separated out from other waste from electrical and electronic equipment and this plastic has to be recycled, incinerated or deposited at approved facilities. In the case of recycling, the plastic has to be used for products for which special requirements apply for fire safety reasons, according to the Ministry of Environment and Energy's Statutory Order No. 1067 of 22 December 1998. • In the United Kingdom, incineration processes should meet an emission standard for chlorinated dioxins of 1,0 ng TEQ/m3 (Environmental Protection Act 1990). Given the similarities between chlorinated and brominated dioxins and the mechanism of their formation, incinerator design and abatement technologies employed for chlorinated dioxins and furans should also be effective in limiting the emissions from the brominated analogues
Norway proposes a prohibition of TBBP-A as additive flame retardant in consumer products with more than 1% TBBP-A by weight in the product's

[27] Rita Gross et al, Final Report "Study on Hazardous Substances in Electrical and Electronic Equipment, Not Regulated by the RoHS Directive" for DG ENV, Oeko Institut 2008

homogeneous components parts (SFT 2007a & SFT 2007b).
On European level TBBP-A has been proposed by the European Parliament to be included in the list of priority substances of the Water Framework Directive, however the final compromise package adopted by the European Institutions finally rejected the substance as priority substance.
EU RAR in accordance with Council Regulation (EEC) 793/93 (repealed by the REACH Regulation)

The European brominated flame retardant industry has included TBBPA in the VECAP (Voluntary Emissions Control Action Programme). VECAP was set up to manage, monitor and minimise industrial emissions of brominated flame retardants into the environment through partnership with the supply chain including small and medium-sized enterprises (SMEs).

Scientific references regarding the environmental impacts associated with the formation of dioxins and furans when TBBPA is used are presented in Annex 6.10.1.

3.5.3.3 Rationale of Criterion 9 point c. related to plastics

Criterion 9 point c. is similar to the EU Ecolabel criteria for notebooks and computers. Moreover, this criterion is also used in the Blue Angel and in Nordic Swan criteria. One of the results of this criterion is the reduction of chlorine content in plastics similar to the case of bromine (i.e. via TBBPA) this would reduce the precursors for the formation of chlorinated dioxins and furans (PCDD/PCDF) and halogenated dioxins and furans (PXDD/PXDF).

Another result of this criterion would be to ensure enhanced recyclability of the plastics parts of imaging equipment. With the current formulation of the criterion the use of PVC will practically be excluded. Complications and impacts regarding the end of life management of plastics containing PVC are given in Annex 6.13.

3.5.3.4 Rationale of Criterion 9 point d related to plastics

Criterion 9 point d. is similar to the EU Ecolabel criteria for notebooks and computers. The use of biocides is addressed in the MS Ecolabels for imaging equipment as well for other product groups. Directive 98/8/EC Annex IA[28] includes the list of active substances with requirements agreed at community level for inclusion in low-risk biocidal products.

[28] Official Journal of the European Communities, DIRECTIVE 98/8/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL concerning the placing of biocidal products on the market, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:123:0001:0063:EN:PDF

3.5.3.5 Rationale of Criterion 9 point e. related to brominated aromatic substances

Ecolabel Regulation 66/2010 demands that in the process of determination of the Ecolabel criteria the substitution of hazardous substances by safer ones shall be considered. This substitution can be as such or via the use of alternative materials or designs, wherever it is technically feasible and together with the potential to reduce environmental impacts due to durability and reusability of products.

Brominated aromatic flame retardants are substances which are used in plastics as additives in order to achieve flame retardant properties, and are addressed in other Ecolabel schemes. In Blue Angel brominated aromatic flame retardants are excluded as they fall under the category of "halogenated polymers and additions of organic halogenated compounds as flame retardants" which are not permissible in plastics of casings and casing parts. The same is applicable for the Nordic Swan Ecolabel in which it is stated that "additives containing organo-halogen compounds are not permitted (this includes flame retardants)". The aforementioned Ecolabel criteria of Blue Angel and Nordic Swan have been applied in praxis with positive effects.

In Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) in Annex II it is required that *"plastics containing brominated flame retardants"* are removed from any separately collected WEEE and are disposed of or recovered in compliance with Article 4 of Council Directive 75/442/EEC on Waste. In this Article 4 of Directive 75/442/EEC Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment.

This removal obligation for brominated flame retardants is expected to reduce the amount of plastics available for recycling and hinder the meeting of recycling targets in plastic dominated WEEE categories as reported in the 2008 review report on WEEE Directive for DG ENV by United Nations University[29]. In the same report it is also stated that: "although very little information on WEEE treatment capacity in the EU27 Member States is available it can be calculated that on average a recovery of 10 % of total equipment weight could be

[29] Huisman, Jaco, Delgado Clara, Magalini Federico, Kuehr Ruediger, Maurer, Claudia Artim, Eniko Szlezak, Josef Ogilvie, Poll Jim, Steve Abs, final Report for DG ENV, 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE), United Nations University, 2008

achieved through the recovery of plastic polymers. As the average plastic content in electronic waste is about 20 %, the fulfilment of the recovery targets may involve recovering half the plastic present in WEEE and recycling 25 %. However the current recovery of polymers from electronic waste is limited and the actual recycling figures are some distance from these objectives."

The reasons for the Criterion 9 point e proposal on the use of brominated aromatic additives used as flame retardants in plastics stem from the environmental concerns associated with the end-of-life phase of imaging equipment. As the vast majority of the currently applied organo-halogenated flame retardants are brominated aromatics and the environmental concerns relate mainly to these substances in Criterion 9 it is proposed to refer to Br-aromatic substances instead of halogenated flame retardants which is the term used in the current Member State labels.

Table 3: Brominated additives addressed in regulations

Substances	Abbreviation	**N° CAS**	REACH annex XIV	REACH candidate List (SVHC)	REACH annex XVII	RoHS 2011/65/EU	Stockholm convention (POP)	Rotterdam convention*
Polybrominated biphenyls (mix)	PBB	59536-65-1			X	X	X	The following N° CAS 36355-01-8* (hexa-) 27858-07-7* (octa-) 13654-09-6* (deca-)
Commercial mixture of Penta bromo diphenyl ether *with the N° CAS of the main components given*	C-pentaBDE	5436-43-1 60348-60-9					X	
Penta bromo diphenyl ether	pentaBDE	32534-81-9			X	X	X	
Commercial mixture of Octa bromo diphenyl ether *with the N° CAS of the main components given*	C-octa BDE	68631-49-2 207122-15-4 446255-22-7 207122-16-5					X	
Octa bromo diphenyl ether	octaBDE	32536-52-0			X	X	X	
Deca bromo diphenyl ether	decaBDE	1163-19-5				X		
Hexabromocyclododecane	HBCD or HBCDD	25637-99-4 3194-55-6 134237-50-6 134237-51-7 134237-52-8	X	X				

In order to allow a better readability of this report, the line of reasoning for proposing Criterion 9 point e. is given below. This is based on the conclusions of a more detailed analysis about the use of brominated aromatic substances which is presented in Annex 6.11.

In general, management of post consumption waste flows can vary widely based on the type of waste management schemes used in various countries and different materials involved. Based on the waste management hierarchy pyramid, the priority has reuse followed by recycling, thermal energy recovery and disposal. The relevant environmental concerns raised for each option of waste management of plastics containing brominated aromatic substances are presented.

The share of plastics which is recycled is relatively low[29] when compared with other materials due to the relative low economic value of the recyclates. It is common practise that mixed plastic fractions from electronic waste are not normally reused in electronics but are mostly "downcycled" into less demanding applications [29] [30]. In these processes health and environmental considerations detected are as follows:

- in some cases brominated aromatic (BFR) substances (i.e. PBDE) can form brominated dibenzofurans, even during necessary recycling operations like extrusion and molding of new plastic products requiring elevated temperatures[31] [32] [33];
- Workers in industrial countries can be exposed to high levels of brominated flame retardants and other toxic chemicals during the recycling of e-waste (including the plastic fraction) [34] [35]. In industry reports it has been concluded that mechanical recycling of such plastic waste is not recommended [31] [36] ;

[30] Manufacturer stakeholders input
[31] Meyer H, Neupert M, Pump W. Flammschutzmittel entscheiden u¨ber die Wiederverwertbarkeit. Kunststoffe 1993;83:253–7
[32] McAllister, D.L.,Mazac, C.J.,Gorsich, R.,Freiberg, M. Tondeur, Y., (1990). Analysis of polymers containing brominated diphenyl ethers as flame retardants after molding under various conditions. Chemosphere 20: 1537-1541,
[33] Weber, R. Kuch, B., (2003). Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated-chlorinated dibenzodioxins and dibenzofurans. Environ Int 29(6): 699-710
[34] Sjődin, A.,Carlsson, H.,Thuresson, K.,Sjolin, S.,Bergman, A. Ostman, C., (2001). Flame Retardants in Indoor Air at an Electronics Recycling Plant and at Other Work Environments. Environ Sci Technol 35(3): 448-454
[35] Stapleton, H.M.,Sjődin, A.,Jones, R.S.,Niehuser, S.,Zhang, Y. Patterson, D.G., (2008). Serum Levels of Polybrominated Diphenyl Ethers (PBDE) in Foam Recyclers and Carpet Installers Working in the United States. Environ Sci Technol 42(9): 3453-3458
[36] Mark, F.E. Lehner, T. (2000). Plastics Recovery from Waste Electrical & Electronic Equipment in Non-Ferrous Metal Processes, Association of plastic manufactures in Europe

- Recent studies revealed that the downcycling of plastic containing brominated flame retardants used as parts of household goods [37] , video tape casings [38] and plastic children toys [39] takes place in uncontrolled conditions for BFR-containing plastics. These practices dilute BFRs in plastic streams, leading to unnecessary human exposure to products containing plastics from recycled materials.

In conclusion, although the share of recycling of plastics is low, the presence of brominated aromatic additives it is still associated with health risks and environmental burdens. Several difficulties have been identified in recycling of plastics of waste of electric and electronic equipment and are presented in more detail in Annex 6.11.3 and 6.12.3.

With regard to the incineration and thermal treatment of plastics containing brominated aromatic flame retardants the environmental concerns are related to the formation of Br-dioxins (PBDD) and Br-furans (PBDF), and in case of Cl presence Br/Cl-dioxins and -furans (PXDD and PXDF). The health and the environmental concerns related to the toxicity of these dioxins and furans are very high (see also Annex 6.11.6). The formation of these pollutants is very limited only in the case of controlled combustion conditions when incinerators are operating under best available technologies (BAT) conditions.

However, it is considered that a high share of e-waste (including waste of imaging equipment) does not end up in these types of incinerators as significant amounts of electronic equipment is exported as articles for reuse (second hand products) to developing/ transition countries as given in Annex 6.12. In these destination countries imaging equipment recycling and thermal treatment is performed under non-BAT conditions[40]. Thus, when brominated aromatic substances are used this leads to health and environmental burdens due to the dioxin/furan formation – burdens which can be avoided by a different substance selection in the design phase of the product. Moreover, when brominated flame retardants

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[37] Chen, S.-J.,Ma, Y.-J.,Wang, J.,Tian, M.,Luo, X.-J.,Chen, D. Mai, B.-X., (2010). Measurement and human exposure assessment of brominated flame retardants in household products from South China. Journal of Hazardous Materials 176(1-3): 979-984

[38] Hirai, Y. Sakai, S.-i. (2007). Brominated Flame Retardants in Recycled Plastic Products. BFR2007: 4th International Symposium on Brominated Flame Retardants

[39] Chen, S.-J.,Ma, Y.-J.,Wang, J.,Chen, D.,Luo, X.-J. Mai, B.-X., (2009). Brominated Flame Retardants in Children's Toys: Concentration, Composition, and Children's Exposure and Risk Assessment. Environ Sci Technol 43(11): 4200-4206

[40] Siddharth Prakash, Andreas Manhart, Yaw Amoyaw-Osei, Obed Opoku Agyekum "Socio-economic assessment and feasibility study on sustainable e-waste management in Ghana for Inspectorate of the Ministry of Housing, Spatial Planning and the Environment of the Netherlands (VROM-Inspectorate) and the Dutch

are used in chlorine and bromine-based polymers, or plastic parts which contain PBBs (polybrominated biphenyls), PBDEs (polybrominated diphenyl ethers) or chlorinated paraffins the potential of dioxin and furans formation is very high. Hence, when brominated flame retardants are present together with the aforementioned substances and materials even for articles weighting lower than 25g proposed Criterion 9 point e. restricts their use. This is in line with the respective Ecolabel criteria found in Member State Ecolabels in which requirements on the use of halogenated flame retardants in plastics are set.

With regard to the disposal in landfills option, it is estimated that a large share of e-waste including imaging equipment waste, ends up in landfills. There is evidence that brominated flame retardants, including POPs and PBDEs leach from landfills (including landfills in industrialized countries) and are contaminating the environment [41] [42] [43] [44].

In should be highlighted that in engineered landfills equipped with bottom liners, leachates that escape to the environment can be collected and treated to reduce the flow of contaminants to ground and surface water for some time [43]. Nevertheless, such treatments are expensive, and because of the persistence of these substances, POPs/PBDEs will remain in landfill body for many decades. Over these long time frames, landfill engineering systems, including basal and capping liners, gas and leachate collection systems, will inevitably degrade and lose their ability to contain the contaminants [45] [46] [41]. Therefore, landfilling does not appear to be a sustainable solution for long-term containment of materials contained brominated flame retardants.

In conclusion, the end-of-life management of imaging equipment, in which brominated aromatic substances are used in plastics, entails health and environmental risks.

Association for the Disposal of Metal, and Electrical Products (NVMP), Oeko Institute 2010, http://www.oeko.de/oekodoc/1057/2010-105-en.pdf

[41] Danon-Schaffer, M.N. (2010). Polybrominated Diphenyl Ethers in Landfills from Electronic Waste Feburary 2010.Vancouver, Faculty of Graduate Studies (Chemical and Biological Engineering) University of British Columbia. PhD:394.

[42] Oliaei, F.,King, P. Phillips, L., (2002). Occurrence and concentrations of polybrominated diphenyl ethers (PBDE) in Minnesota environment. Organohalogen Compounds 58(185–188)

[43] Osako, M.,Kim, Y.-J. Sakai, S.-i., (2004). Leaching of brominated flame retardants in leachate from landfills in Japan. Chemosphere 57(10): 1571-1579

[44] Oliaei, F.*,Weber, R. Watson, A., (2010). PBDE contamination in Minnesota Landfills, waste water treatment plants and sediments as PBDE sources and reservoirs Organohalogen Compounds 72

[45] Buss, S.E.,Butler, A.P.,Sollars, C.J.,Perry, R. Johnston, P.M., (1995). Mechanisms of Leakage through Synthetic Landfill Liner Materials. Water and Environment Journal 9(4): 353-359

[46] Allen, A., (2001). Containment landfills: the myth of sustainability. Engineering Geology 60(1-4): 3-19

- Plastic containing brominated aromatic substances has a negative influence on the recycling of imaging equipment as the plastic fraction containing BFR needs to be removed from any separately collected WEEE and disposed of or recovered with specific requirements based on the provisions of Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). Difficulties on WEEE are presented in more detail in Annex 6.12.3
- A large proportion of brominated flame retarded materials are combusted. Depending on the quality of combustion, high levels of brominated dioxins and furans can be formed and released as a result of the dioxin precursor properties of aromatic brominated flame retardants. In particular, open burning of e-waste is estimated to globally generate PBDD/PBDFs and PXDD/PXDFs on a scale of tons and for many geographical areas can be considered as common practice. More information on this is presented in Annex 6.11.4. The toxicity and environmental concerns related to dioxins and furans are high (see Annex 6.11.6). Brominated flame retardants in plastics can be destroyed with high efficiency only if the plastics are treated in incinerators constructed and operating according to best available technology (BAT) and best environmental practices (BEP). However, in this case costs per ton of incinerated material are considered high (in the order of $100/t).
- Additionally, a large portion of Bromintaed FR-treated products end up in landfills and there is growing evidence and concern that brominated flame retardants including POPs/PBDEs are leaching from landfills and contaminating the environment in industrial countries as well as in developing/transition countries. Only in engineered landfills with bottom liners, leachates that escape to the environment can be collected and treated to reduce the flow of contaminants to ground and surface water for some time but such treatments are expensive and not state-of-the art. Because of their persistence, POPs/PBDEs will remain in landfills for many decades – and probably centuries and are expected to be eventually released to the environment as the landfill engineering systems (including basal and capping liners, gas and leachate collection systems) will inevitably degrade and lose their ability to contain the contaminants. Therefore, land filling does not appear to be a sustainable solution for long-term containment of brominated FR-treated materials. More information is presented in Annex 6.11.5.
- Alternative material and substitutes of brominated aromatic additives used as flame retardants is available i.e. in the Member StatesStates Ecolabelled imaging equipment thus Criterion 9 is proposed.

3.5.4 Rationale of criteria related to mercury in fluorescent lamps and batteries (criterion 10)

Mercury and its compounds are highly toxic to humans, ecosystems and wildlife, including risk of serious, chronic, irreversible adverse neurotoxic and neurodevelopmental effects. Public awareness has increased about the health and environmental concerns related to mercury. Actions towards a reduction of the use of mercury in products have been undertaken for many years, most recently with the current pending proposal of ECHA regarding Mercury in measuring devices[47]. The release of mercury from imaging equipment is thought to take place mainly during the waste phase. Mercury is mainly contained in scanning unit lamps and the LCD control panel backlights.

Fluorescent lights are classified as hazardous under the European Hazardous Waste Directive because of their mercury content. Annex II of the WEEE Directive requires that the mercury be removed from these lights. Currently there are two methods for removing mercury from fluorescent lamps. One method is to cut the end off of the tube and remove the mercury and phosphor powder, and the second is to shred the complete light and then mechanically separate out the powder. More information on this is given in Annex 6.5.

In the study for DG ENTR regarding the RoHS and WEEE Directives[48] it is reported that although the amount of mercury in copiers and printers had been significantly reduced, there could be still be up to 84 g per copier (up to 0.1%). Criteria 14 is set in the context of a widely recognized need to further reduce mercury emissions at an EU level and apply the strategy to avoid pollution at source.

Today, LED lamps are becoming more common in these appliances (e.g. scanners and photocopiers) and replace mercury-containing fluorescent lamps. LEDs often provide additional benefits, such as longer lifetimes and energy efficiency. Additionally, according to stakeholders, the environmental benefits of using LEDs outweigh their impacts which are

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[47] European Environmnetal chemical Agency, Restrictions under considerations: http://echa.europa.eu/reach/restriction/restrictions_under_consideration_en.asp

[48] Sarah Bogaert, Mike Van Acoleyen, Inge Van Tomme, Lieven De Smet, Dave Fleet, Rocio Salad, Final report: Study on RoHS and WEEE Directives N° 30-CE-0095296/00-09 project for European Commission DG Enterprise and industry, March 2008 http://www.rsjtechnical.com/images/Documents/RoHSreview_simplification_Mar08.pdf

related to resource depletion potentials (i.e. use of gallium, energy intensive manufacturing process).

In the EU Ecolabel for laptops and computers, a criterion similar to Criterion 10 regarding the use of Mercury in fluorescent lamps has been introduced. Other ecolabeling schemes like the US epeat in their current developments also propose criteria for Mercury in fluorescent lamps.

3.6 Reuse, recycling and end-of-life management

3.6.1 Formulation and verification of criteria on reuse, recycling and end-of-life management area

The following three criteria fall under the category of reuse, recycling and end-of-life management. Their proposed formulation and verification are given below.

3.6.1.1 Criterion 11 - Design for disassembly

The following formulation is proposed:

The manufacturer shall demonstrate that the imaging device can be easily dismantled by professionally trained personnel using the tools usually available to them, for the purpose of repairs and replacements of worn-out parts, upgrading older or obsolete parts, and separating parts and materials, ultimately for recycling or reuse. The applicant shall complete the "checklist for recyclable design" which is given in Annex 6.7.

Assessment and verification

A test report shall be submitted with the application detailing the dismantling of the imaging equipment device. It shall include an exploded diagram of the product, labelling the main components as well as identifying any hazardous substances in components. It can be in written or in digital format. Information regarding hazardous substances shall be provided to the competent body. The applicant shall comply with all the mandatory parts listed in the "checklist for recyclable design." The applicant shall name the casing plastics used for parts over 25 grams and submit a list of plastics attached to the application in the form of a list of materials identifying material type, quantity used and location.

3.6.1.2 Criterion 12 – Recycled and reused content

The following formulation is proposed:

The external plastic casing parts shall have in total a post-consumer recycled and reused content of not less than 10 % by mass.

The total post-consumer recycled content and the reused content of the external plastic parts shall be declared in the user information.

Assessment and verification

The applicant shall provide the competent body with a declaration stating the percentage of post-consumer recycled content and/or reused content of the plastic parts of casing. The applicant shall provide a sample of the user information to the awarding competent body.

3.6.2 Rationale of criteria on reuse, recycling and end-of-life management (criteria 11-12)

Criterion 11 - Design for disassembly, is mainly based on the respective criterion on Recyclable Design of Blue Angel, which was presented as an option at the 1st AHWG meeting. Many stakeholders agreed to this criterion and, as the experience showed in Blue Angel, its application is considered beneficial, hence it is also proposed for the EU Ecolabel. The criteria area of design for disassembly is found in every Ecolabel scheme (see also Technical Background Report for the 1st AHWG).

In EU Ecolabel criteria sets for similar products, i.e. EU Ecolabel for notebooks, this issue is also addressed. This criterion is linked to the environmental area of resource depletion which is addressed in Article 6.3 of EU Ecolabel Regulation 66/2010. The aim of this criterion area is to facilitate reuse[49] and recycling[50] of materials (thus reducing in this way the amount of new resources which have to be used if the end-of-life materials are not recovered) and to avoid design options which hamper the recovery.

However, this criterion is related to environmental savings via reduced resource consumption only when the device is eventually channelled for reuse and/or recycling. This was discussed

[49] Reuse is defined here as: the use of part of the product for its original intended purpose, with or without prior repair or refurbishment

[50] Recycling is defined here as: Processing parts of the products for retrieval of usable components or for recovery of material, including the processing of plastic materials for re-processing it in plastics manufacturing and the processing of metals for recovery of precious metals, or for resale as commodity scrap metal.

at the 1st AHWG meeting. It was emphasized that the existing Ecolabeling schemes, despite set requirements related to this criterion, cannot in praxis ensure that the device will be sent for reuse and recycling, as the latter is affected from several parameters (e.g. user behaviour, availability of collection systems, and other issues such as sending the products abroad to third countries, where the respective practices cannot be controlled) not possible to be controlled via an Ecolabel scheme.

In addition, in many product groups Ecolabel criteria which set requirements related to a mandatory use of recycled material are found (i.e. Nordic Swan, Blue Angel, EU Ecolabel, Epeat etc.). Resource consumption is an important area for the product group under study, and reuse and recycling play an important role in this regard. This area is in Article 6.3 of Ecolabel Regulation explicitly addressed[51].

In the manufacturer's sustainability reports is addressed the importance of resource efficiency and reuse and/or recycling activities are reported[52]. However, it shall be kept in mind that environmental impacts are also associated with recycling processes. The environmental break even point (which is defined as the recycling rate point of the material in which the environmental impacts of it are equal with the environmental impacts of a virgin material) varies among different material and generalization on this is not always straightforward. However, a positive balance is expected for low and very low recycling rates (under 30 %).Reporting the content of reused and recycled material in the products is of relevance for the product group of imaging equipment. Therefore, with Criterion 12 – Recycled and reused content, data shall be collected to allow for obtaining important information on the state-of-the-art, best performing products in the market. This could allow benchmarks to be set for the next revision in this area which is an area addressed explicitly in Article 6.3 of Ecolabel Regulation[53].

In the EU Ecolabel criteria for PCs as well in the ones for notebooks a minimum threshold value is set. Criterion-recycled content in these EU Ecolabel criteria decision documents is formulated as flows: "the external plastic case of the system unit, monitor and keyboard shall have a post consumer recycled content of not less than 10 % by mass".

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[51] In art. 6.3 EU Ecolabel Regulation 66/2010 is stated that: In determining Ecolabel criteria, the potential to reduce environmental impacts due to durability and reusability of products shall be considered.

[52] See also "Working Document Input to 1st AHWG on 21st March 2011", Institute for Prospective Technological Studies/ Joint Research Centre, March 2011

[53] In art. 6.3 EU Ecolabel Regulation 66/2010 is stated that: In determining Ecolabel criteria, the potential to reduce environmental impacts due to durability and reusability of products shall be considered.

Regarding reuse in the product group of imaging equipment BAT-products have been identified. These BAT-products are specially designed for reuse and are marked business to business (B2B). The overall reuse rate for these products reaches 82%[54]. Nonetheless, these examples are currently limited either to pilot programs or to geographical regions outside EU-27 i.e. Japan and Hong Kong. Further, reuse is not a common practise among manufacturers despite the fact that reuse (according to the waste management hierarchy) is preferred over recycling.

It is suggested therefore to set a minimum requirement on the total reused and recycled content. This is considered to give an incentive to manufacturers to explore and integrate in their future developments better performance solutions regarding this issue. In order to allow the best performing products to benefit from their high reuse and recycling rates, it is suggested that the user shall be directly informed about this aspect (as proposed later in Criterion 18).

3.7 Ink and toner consumables

3.7.1 Formulation and verification of criteria for ink and toner consumables

The following three criteria fall under the category of ink and toner consumables.

3.7.1.1 Criterion 13 - Design for recycling and/or reuse of toner and/or ink cartridges

The following formulation is proposed:

The products must accept remanufactured toner and/or ink cartridges.

The applicant shall ensure that any cartridge produced or recommended by the manufacturer (OEM) for use in the product is designed for reuse. The applicant shall provide to the user information how many reuse circles are recommended (a minimum of one is required) and ensure that the performance of a reused cartridge, can reach printing and/or copying performance level equivalent to a new one.

The design of the cartridge should also promote material recycling.

This requirement is not applicable for imaging equipment applying the solid ink technology.

Assessment and verification

The applicant shall declare compliance with the requirements. The applicant shall provide to the competent body a copy of the user information. If requested by the competent body the applicant shall submit instructions on how the cartridge shall be remanufactured and/or refilled. The competent body may ask the applicant to provide a proof (i.e. one sample) that cartridges can be remanufactured or refilled following the provided instructions.

3.7.1.2 Criterion 14 - Toner and/or ink cartridge take-back requirement

The following formulation is proposed:

The applicant shall ensure the return of toner/ink modules and toner/ink containers supplied or recommended by the applicant for use in the product back to the applicant, and channel such modules and containers to reuse or material recycling with preference given to reuse. This also applies to residual toner containers.

Third parties (dealers and service agencies or companies engaged in the module recycling business) may be subcontracted to perform this task. The formers shall be provided with instructions for proper handling of residual toner. Non-recyclable product parts shall be properly disposed. Modules and containers shall be taken back free of charge by the return facility named by the applicant to which products may be returned personally or by shipment. The product documents shall include detailed information on the return system.

Assessment and verification

The applicant shall declare compliance with the requirements and document instructions for the recycling contractor for dealing with residual toner (e.g. by means of the EC Material Safety Data Sheet) and by means of the note: "Prevent toner dust from being released into the air." A declaration that the toner/ink modules and toner/ink containers are channelled for reuse and/or recycling signed by the subcontracted third parties (dealers and service agencies or companies engaged in the module recycling business) shall also be provided to the awarding competent body.

3.7.1.3 Criterion 15 - Substances in ink and toners

The following formulation is proposed:

[54] http://www.ricoh.com/environment/product/resource/02_01.html

a. No substances may be added to toners and inks supplied or recommended by applicant for use in the product which contain mercury, cadmium, lead, nickel or chromium-VI-compounds as constituents. Exempted are high molecular weight complex nickel compounds as colorants. Production-related contamination by heavy metals, such as cobalt and nickel oxides shall be kept as low as technically possible and economically reasonable.
b. Azo colorants that might release carcinogenic aromatic amines appearing on the list of aromatic amines according to Regulation (EC) No 1907/2006 annex XVII, shall not be used in toners and inks supplied or recommended by the applicant for use in the product.
c. Only those substances which are listed as so-called existing substances in Annex II to Commission Regulation EC 2032/2003 amended by Regulation EC 1048/200512 may be added as active biocides to inks supplied or recommended by the applicant for use in the product.

Assessment and verification

The applicant shall declare compliance with the requirements. A declaration of compliance signed by the ink and toner supplier(s) and copies of relevant Safety Data Sheets about materials and substances shall also be provided to the awarding competent body.

3.7.2 Rationale of criteria on reuse, recycling and end-of-life management (criteria 13-15)

Criterion 13 addresses the area of reuse and recycling of cartridges. In the framework requirements set by the EU Ecolabel Regulation 66/2010, one of the issues addressed is the potential to reduce environmental impacts due to durability and reusability of products to which this criterion is related. The aim of this criterion is to facilitate reuse and recycling of materials (thus reducing in this way the amount of new resources which have to be used if the end-of-life materials are not recovered) and to promote the products which are designed that way.

The importance of reuse and recycling of cartridges was presented in the Technical Background Report, discussed and agreed upon as an important area to draft Ecolabel criteria in the 1st AHWG meeting, and is an area for which criteria are found in Blue Angel and Nordic Swan. Reuse and material recycling strategies on ink and toner cartridges contribute to resource conservation and to waste reduction.

The start point of Criterion 13 is the proposed industry voluntary agreement with regard to the Ecodesign Directive for ErP. Based on this in the European market the manufacturers signing this are committed that "for all products placed on the market after 1 January 2012, any cartridge produced by or recommended by the OEM for use in the product is not designed to prevent its reuse and recycling". In the proposed Criterion 13 it is considered that the above given formulation could be also expressed in a positive way thus, the cartridges shall be designed for reuse and recycling. In general based on the waste management hierarchy pyramid the priority has reuse followed by recycling, energy recovery and disposal. Thus, reuse shall be given priority over recycling. This is also expressed in the current Ecolabel and Blue Angel criteria, and many stakeholders agreed with it in the 1st AHWG meeting.

In this area, manufacturing stakeholders presented data of a recent footprint-LCA study. In the particular LCA case study, the net footprints of both the new cartridge (which is assumed to have material recycling in its end-of-life phase) and the remanufactured cartridge (which is assumed to be exposed to the landfill) are about equal, with the remanufactured version having a slightly larger environmental impact overall. Thus, even under specific assumptions the benefit of reuse and recycling is proved to be high and in general it is concluded that: reuse of toner cartridges can deliver the best carbon avoidance benefits, but only if product performance and ultimate end-of-life disposal are optimized. More details on this are given in Annex 6.15.

It shall be emphasised at this point that this criterion is related to environmental savings via reduced resource consumption only when the device is eventually channelled for reuse. Therefore it is important that not only the design of the cartridge shall allow its reuse, but also the user be informed of the potential to reuse the cartridge.

For the LCA study investigations were carried out and both OEM cartridge producers and cartridge remanufacturer stakeholders were consulted via a respective questionnaire. The response to this was mainly from cartridge remanufacturer stakeholders as many imaging equipment manufacturers consider that a proper recycling of the cartridges could achieve sufficient environmental benefits (as mentioned before i.e. footprint LCA study and given in

Annex 6.15). The main outcomes of this consultation (questionnaire feedback) are given below:

1. with regard to cartridge waste volumes and reuse rates of cartridges, stakeholders suggest that:
    a. 300-500 million ink cartridges and 10-20 million toner cartridges are annually sold in the EU-27;
    b. an estimated 20 % (at least) of these cartridges are reused.
    c. A few OEM producers are involved in remanufacture activities whereas many are involved in recycling activities;
    d. It is estimated that in total volume per year the 40 -70 % of the cartridges end up in landfills and/or incinerators.
2. with regard to the cartridge reuse circles stakeholders suggest that:
    a. It is estimated that ink and toner cartridges can be reused at least once but on average two-three times, and printing quality remains sufficient at this level of reuse;
    b. Toner cartridges can be remanufactured more easily than ink cartridges and there are extreme examples of up to 25 reuse circles;
    c. Some parts have to be changed in the remanufacturing process;
    d. The number of reuse circles depends on the model and the condition of the collection of the cartridge.
3. with regard to parameters affecting the cartridge reuse circles stakeholders suggest that:
    a. This is a very complex area and there several parameters affecting the reuse of the cartridge which vary based on the type and model of the cartridge. In cases of remanufacturing of OEM cartridges via cartridge return programs obviously there are no problems. However, for cartridge remanufacturing by third parties the identified technical parameters can be summarised in:
        i. clever/killer/smart chips;
        ii. design features that hamper remanufacturing i.e. welding, glue, blind screws or conjoined parts to fit cartridge-parts together;
        iii. Weaker print heads.
    b. Legal barriers because of patents

In conclusion, the potential for achieving environmental savings and resource conservation via reusing cartridges is high as the majority of them are disposed after the first use. Reuse has either better or coequal environmental benefits as recycling, thus it shall be prioritised as an option. This is in line with the waste management hierarchy and with priorities set in the MS Ecolabel criteria for imaging equipment and for remanufactured cartridges. Criterion 13 also includes that the design of the cartridges shall also facilitate recycling.

The cartridge reuse circles depend on the type, model and the collection system, however, based on the stakeholders, a cartridge can be reused at least one time but the average is three times with a high improvement potential as there are examples of cartridges which were reused up to 25 times. As the number of reuse circles is not definite for each cartridge it is suggested that no threshold values on the cartridge reuse circles shall be given in this phase but instead allow manufacturers to determine thresholds based on the case specific parameters.

The technical parameters which can affect the reuse are numerous and vary based on the type of cartridge and the model. However, practice shows that when a cartridge is designed for reuse these barriers are not present. Hence, in Criterion 13 it is proposed to design the cartridges for reuse. Freedom given to the designer on how to achieve this goal is considered of importance as no eco-innovation shall be hampered. For verification a demonstration, if requested by the competent bodies, on how a cartridge can be reused is considered to be sufficient.

Criterion 14 - Toner and/or ink cartridge take-back requirement, is based on the respective criterion on of Blue Angel, which was discussed as an option in the 1st AHWG meeting. Many stakeholders agreed to this criterion and, as the experience showed in Blue Angel its application is considered beneficial, hence it is also proposed for the EU Ecolabel.

Criterion 15 - Substances in ink and toners is based on the respective criterion of Blue Angel. This criterion area was presented as an option in the 1st AHWG meeting and stakeholders agreed to it. Similar requirements are set also in Nordic Swan criteria. Ink and toners are a different product group from imaging equipment and are also marked separately. Ink and toners are consumables of imaging equipment and their manufacturers are also ink and toner producers. Therefore, to the extent it is possible, the main health and environmental impacts related to the use of substances in these items shall also be covered in the Ecolabel criteria for imaging equipment. This was agreed in the 1st AHWG meeting and based on current experience the main health and environmental impacts are covered by up taking the current Member State criteria. A more comprehensive option for substances found in the ink and toner consumables could be to apply the same requirements as set in Criterion 7.

However, as presented in section 3.5.2.2 this raises many practical difficulties and could be better covered in Ecolabel criteria of the product group of ink and toners.

3.8 Corporate Criteria

3.8.1 Formulation and verification of corporate criteria

The following four criteria fall under the category of corporate criteria. Their proposed formulation and verification are given below.

3.8.1.1 Criterion 16 - Requirements on packaging

The following formulation is proposed:

Where cardboard boxes are used for the final packaging, they shall be made of at least 80 % recycled material.

Where plastic bags are used for the final packaging, they shall be made of at least 75 % of recycled material or they shall be biodegradable or compostable, in agreement with the definitions provided by the EN 13432 or equivalent.

Assessment and verification

A sample of the product packaging shall be provided, together with a corresponding declaration of compliance with this criterion. Only primary packaging, as defined in European Parliament and Council Directive 94/62/EC (2), is subject to the criterion.

3.8.1.2 Criterion 17 – Warranty, guarantee of repairs and supply of spare parts

The following formulation is proposed:

The applicant shall ensure guarantee for repair or replacement of minimum five years.

The applicant shall ensure that a supply of spare parts and necessary infrastructure for equipment repair is available for a period of at least 5 years after the end of production and that users are informed about the guaranteed availability of spare parts.

Assessment and verification

The applicant shall declare to the competent body the guarantee of repairs and supply of spare parts and provide samples of the product information sheet and warranty terms to the awarding competent body.

3.8.1.3 Criterion 18 - User Information

The following formulation is proposed:

The applicant shall inform the user as follows:

(a) Environmental relevance of paper consumption

"The main environmental impacts of this product along its life cycle are related to the consumption of paper. The less paper is used the lower the overall life cycle environmental impacts. It is recommended to apply double side printing and to print multiple pages in one paper sheet."

(b) Printouts produced after cancelation

The applicant shall declare the maximum number of pages which are printed or copied after the user has cancelled the printing or copying process. The measurement shall be conducted using the measurement procedure described in Annex 6.1.

(c) Noise

"This device has noise emissions L_{WAd} > 63.0 dB(A) and is not suitable for use in rooms where people do primarily intellectual work. This device should be placed in a separate room because of its noise emission".

This information shall only be given when the measured A-weighted sound power level of the device exceeds the 63.0 dB(A) as measured for criterion.

(d) Resource efficiency

"This product is resource efficient. Plastic content of casing parts is comprised of x% reused plastic and/or y% recycled post-consumer plastic".

Where x is the declared reused plastic content and y is the declared post consumer recycled plastic content.

(e) Ink and toner cartridges:

"The cartridges of this equipment are designed to be reused. It is recommended to reuse the cartridge at least x times."

where x is the recommended number of reuse circles, as specified in criterion 13.

Assessment and verification

A certificate signed by the manufacturer declaring compliance with these requirements and evidence of the required user information shall be provided by the applicant to the competent body. The applicant shall declare the percentages of the post consumer recycled and/or reused content of the casing plastic parts. Printouts produced after cancelation shall be measured following the calculation method proposed in Annex 6.4. The applicant shall fill-in table 4 of Annex 6.4.

3.8.1.4 Criterion 19 - Information appearing on the Ecolabel

The following formulation is proposed:

Optional label with text box shall contain the following text:

— Designed for efficient paper management

— High energy efficiency

— Minimised use of hazardous substances

Assessment and verification

The applicant shall declare the compliance of the product with this requirement and shall provide a copy of the Ecolabel as it will appear on the packaging and/or product and/or accompanying documentation to the competent body.

3.8.2 Rationale of corporate criteria (criteria 16-19)

General regulations concerning the management of packaging and packaging waste are covered by the Directive 94/62/EC[55]. Average life time of imaging equipment are four to six years, thus from a life cycle perspective packaging does not gain high relevance (see also Technical Background Report[7]).

Nevertheless, as also mentioned during the stakeholders meeting, packaging is a horizontal issue, and even if not very relevant for a certain product group, the total mass of packaging used in EU-27 is very significant. EU Ecolabel criteria shall also cover requirements on packaging and packaging waste and signal to consumers its importance. Further, it was emphasised that packaging is the first element with which a consumer comes in contact, and Ecolabelled products, as environmentally preferable products, shall also be distributed in appropriate environmentally friendly packaging, which also facilitates its sound waste management (e.g. easy collection, separation and recycling).

On this basis it is suggested that the generally applicable criteria set in EU Ecolabel decisions for similar product groups shall be proposed for the Ecolabel for imaging equipment. In this case Criterion 16 - Requirements on packaging, is based on the respective criterion found in EU Ecolabel for notebooks.

Criterion 17 – Warranty, guarantee of repairs and supply of spare parts is also in the frame of the corporate criteria. If a product has a shorter lifetime, especially because there are no spare parts, then this has also environmental implications as the purchase of more than one product results to increases environmental impacts related the production and manufacturing life cycle as well as directly to the category of resource depletion. Moreover, a product with a shorter than expected lifetime would also give wrong signals to the market that Ecolabeled product may be of lower quality. It is considered of importance that the Ecolabelled products fulfil the general quality requirements which contribute to its proper functioning over its lifetime. In this proposal Criterion 17 is similarly formulated as the respective criteria of Nordic Swan and Blue Angel. The period of five years is proposed as the average estimated product lifetime is four to six years and is in line with the period used in the aforementioned MS labels.

Criteria related to information for the user are applied in every Ecolabel and have importance as they raise the user awareness on environmental issues which are especially relevant to the particular product group and support environment-friendly behaviour.

Criterion 18 point a. and point b. is proposed due to the fact that the most relevant factor in the life cycle of imaging equipment is related to the consumption of paper. The environmental assessment, conducted in the framework of the study, shows (as explained in detail in the 1st Working Document[8]) that paper consumption, followed by energy consumption in the use

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[55] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste, available online at:

phase, has the most dominant role in the life cycle of imaging equipment influencing the overall environmental product performance. As discussed in the 1st AHWG meeting one of the possible ways to reduce the paper consumption is to reduce the number of unnecessary printouts after cancelation. As the performance of different imaging equipment can vary it is important to allow the user to gain this information and support him to choose the most efficient device whereas the manufacturers have the opportunity to inform the user of their achievements. As stated in section 4.2 a criterion which restricts the number of printouts after cancelation is proposed to be investigated for the next criteria revision.

In Criterion 18 point c. is related to user exposure to noise. This criterion informs the user that due to the noise emissions of the particular device it is recommended to avoid placing it in the same room where people do primarily intellectual work, as noise would cause disturbance. This recommendation is also addressed in the respective criterion of Blue Angel.

Moreover, Criterion 18 d. is related to Criterion 12 and informs the user of the reused and recycled content of the product; hence it raises the user's environmental awareness, demonstrates the importance of reuse and recycling and allows the manufacturers to inform the user of their achievements.

Criterion 18 point e is related to Criterion 13 and intends to support the environmentally friendly behaviour of the user. In order to gain the environmental benefits of reusing a cartridge it is important that the user knows that this is feasible and how many times reuse is recommended.

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http://europa.eu/legislation_summaries/environment/waste_management/l21207_en.htm

3.9 Social Criteria

3.9.1 Formulation and verification of social criteria

3.9.1.1 Criterion 20 – Social accountability

The following formulation is proposed:

Fundamental principles and rights regarding working conditions must be fulfilled during the production of the imaging equipment device.

The licensee must ensure that the production of the product follows the ILO conventions regarding child labour, forced labour, health and safety, discrimination, discipline, hours of work, wages, freedom of association and collective bargaining.

Assessment and verification

The applicant shall declare compliance with this requirement and provide a specification of contracts with inspection authorities and either a code of conduct regarding ILO conventions or a SA8000 certification.

3.9.1.2 Rationale of social criteria

The area of social criteria has been addressed by stakeholders in the 1st AHWG meeting in which it was concluded that the elaboration of social criteria within the EU Ecolabel is at this phase considered as a horizontal issue applicable across the different product groups.

Currently social criteria were introduced recently in the EU Ecolabel criteria for the product group of "light sources". Moreover, as presented in the background report on the definition and scope[56] the sustainability guidelines of UNEP use similar social criteria. In both cases there is a reference to the International labour Organization (ILO) conventions regarding fundamental principles and rights regarding working conditions.

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[56] Jiannis Kougoulis, Oliver Wolf draft "Background Report "Development of EU Ecolabel and GPP criteria for Imaging Equipment-Product definition and Scope", Institute for Prospective Technological Studies/ Joint Research Centre, March 2011

As the electronic sector has established and uses since many years the "Electronic Industry Code of Conduct" the product group is considered for relevant to cover this issue. The latest version is EICC *Version 3.0 (2009)*[57]*.* Some supplementary information on the Electronic Industry code of conduct and the core ILO conventions is presented in Annex 6.16.

[57] http://www.eicc.info/PDF/EICC%20Code%20of%20Conduct%20English.pdf

4 ISSUES PROPOSED TO BE INCLUDED IN THE COMMISSION STATEMENT FOR THE REVISION PROCESS

In the Commission Statement accompanying the criteria document issues which are proposed to be taken into account in the next revision process are indicated. In the current criteria development process several aspects, which shall be considered for the revised criteria set for the product group of imaging equipment, were identified. They are briefly described below.

4.1 Reporting of ultrafine particles emissions

In the 1st AHWG meeting the issue of ultrafine particles emissions was discussed as a potential criterion area which could be covered by the EU Ecolabel criteria in the framework of the indoor emissions criterion. Health impacts due to fine and ultrafine particles (FP and UFP) are an area of intensive research. A direct link between FP and UFP originating from different sources (including i.e. imaging equipment) and health impacts has not been proved.

An important issue is that stakeholders show interest in this and propose to include measurements of UF and UFP in the Ecolabel criteria, as research can unveil wrong implications and/or suspicions. However, thresholds for FP and UFP cannot be proposed at this phase as on the one hand no link between FP/UFP from imaging equipments and health impacts has been proved and on the other hand there are no emission data available in order to identify the best performing products. Nonetheless, we propose to investigate this aspect in the next revision of the criteria in which more knowledge would be available.

4.2 Restriction on the number of printouts after cancelation

The performance of imaging equipment regarding the number of printouts after the printing cancellation varies among different models. The potential to reduce the overall paper consumption and the related environmental impacts along the life cycle of imaging equipment by ensuring low number of printouts produced after the user cancels/interrupts the printing process is considered high.

As the main environmental impacts of imaging equipment are related to the paper consumption, the number of printouts was chosen as a reference parameter.

Currently the data for setting a benchmark on this aspect is not available. Informing the user about the number of printouts for this first version of imaging equipment EU Ecolabel criteria shall allow the end-user to identify easily the product performing best in this respect and in this way to support promotion of manufacturers, who take this aspect into consideration in the product development process.

However, it is further recommended to consider in the next criteria revision process to include a criterion in which the maximum printouts number allowed will be determined.

5 SUMMARY

This working document has been prepared for the 2nd AHWG meeting on the development of EU Ecolabel criteria for imaging equipment. The criteria aim, in particular, at promoting products that have a reduced environmental impact along their life cycle (with regard to e.g energy consumption, global warming, acidification, ecotoxicity, human toxicity, eutrophication, resource depletion). The performance of these products shall be resource efficient and energy efficient, and they shall contain a limited/reduced amount of hazardous substances in comparison with average products available on the market. The criteria further aim at promoting products with low noise levels and contribute to lower indoor air emissions.

Criteria are proposed for the following areas:

1. Paper management
2. Energy efficiency
3. Indoor air emissions
4. Noise
5. Substances and mixtures in imaging equipment
6. Reuse, recycling and end-of-life management
7. Ink and toner consumables
8. Corporate criteria

Based on the environmental assessment conducted, the consumption of paper and of energy in the use phase of the product has been identified to contribute most to the overall environmental impact caused by this product group along the life cycle.

Therefore, high emphasis was given to these key environmental areas, paper management and energy efficiency in the criteria related. For the former several criteria are introduced which promote products which allow and support the user to apply efficient paper management, whereas for the latter the most recent energy requirements of the Energy Star label (which is developed in parallel to the current EU Ecolabel criteria) is proposed.

With regard to the implications of the EU Ecolabel Regulation 66/2010 special focus was given in the area of hazardous substances and mixtures. Criteria which could ensure prevention of use of hazardous substances are proposed. Derogation requests submitted by industry stakeholders for exempting specific substances were investigated.

Applying the EU Ecolabel Regulation 66/2010 implications for preventing environmental impacts related to the use of specific substances further criteria are proposed in the area of substances and mixtures. That way the use of environmentally friendlier substances is promoted. These criteria are also in line with similar criteria found in MS Ecolabel schemes. Life cycle considerations regarding use of these substances and their potential contribution to environmental problems of high concern, e.g. formation of dioxins and furans, hampering recycling, etc., were investigated.

With regard to the area of resource efficiency, criteria are proposed for both imaging equipment and its consumables. The promotion of reuse and recycling practices are the focus of these criteria.

Criteria are also proposed for the area of indoor air emissions and noise. For the former, criteria regarding the emission of indoor pollutants and ultra fine particles are proposed; whereas for the latter, the noise exposure benchmarks are proposed, based on investigation of the noise modelling curves.

Corporate criteria, including user information, guarantee of spare parts and repairs and the information appearing on the EU Ecolabel logo, are also proposed.

The following document is intended as a working paper for a discussion during the 2nd AHWG meeting; therefore we invite the stakeholders to comment on the issues presented in this report and to share their comments with us.

6 ANNEXES

6.1 Reporting of printouts produced after cancelation

The applicant shall report the number of paper sheets which are printed or copied after the user has cancelled the printing or copying process separately for one-side printing and for double-side printing based on the measurement method described below.

Measurement method for the assessment of the reporting of number of printouts produced after cancelation

The following measurement method is proposed:
The devices shall be tested in the following modes while operating in high performance (speed and print quality):

- One side monochrome printing
- Double side monochrome printing
- One side colour printing
- Double side colour printing

In all cases A-4 size paper having a weight per unit area of 70 to 80 g/m2 shall be used for the printouts. The double side printing test is only applicable only for devices equipped with automated duplex unit.

The same monochrome and colour sample will be used as the test sample as was used in the measurement of indoor emissions in Blue Angel Ecolabel criteria RAL-UZ122:2006-04 (also available via http://www.ps.bam.de/RALUZ122E/) originating from JBMS-74-1.

The printing process shall start and shall be interrupted (cancelled) when the forth printout leaves the internal printing part and is in on the respective casing part available and ready for the user to take. The cancelation can be made either using the software cancelling option or if available via a button directly on the hardware.

The number of paper sheets printed after the printing cancelation shall be reported.
The final reported value shall be the average of three tests.
The following table shall be completed:

Table 4 Form for reporting the number of printouts produced after cancelation

Tested operation	Speed in ipm	Number of printouts printed after cancelation
One side monochrome printing		
Double side monochrome printing		
One side colour printing		
Double side colour printing		

In case of copiers the same test measurement procedure shall be used.

<u>Rationale for reporting of printouts produced after cancelation</u>

The performance of imaging equipment regarding the number of printouts after the printing cancellation varies among different models. The potential to reduce the overall paper consumption and the related environmental impacts along the life cycle of imaging equipment by ensuring low number of printouts produced after the user cancels/interrupts the printing process is considered high.

As the main environmental impacts of imaging equipment are related to the paper consumption, the number of printouts was chosen as a reference parameter.

Currently the data for setting a benchmark on this aspect is not available. Reporting the number of printouts for this first version of imaging equipment EU Ecolabel criteria shall allow the end-user to identify easily the product performing best in this respect and in this way to support promotion of manufacturers, who take this aspect into consideration in the product development process. It is further recommended to consider in the next criteria revision process including the criterion regarding the maximum printouts number allowed in the EU Ecolabel criteria set for imaging equipment.

6.2 Energy Star v.2.0 development documents

Here is given an excerpt of the latest document "ENERGY STAR Imaging Equipment Version 2 0 Draft Test Method" regarding the Energy Star 2.0 developments.

ENERGY STAR® Program Requirements
Product Specification for Imaging Equipment

Test Method for Determining
Imaging Equipment Energy Use
Rev. Jul-2011

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Imaging Equipment.

Note: This document contains proposed changes to the ENERGY STAR test methods for both Operational Mode (OM) and Typical Energy Consumption (TEC) imaging equipment products. The proposed changes incorporate the feedback received during and after the imaging equipment webinar held on April 13, 2011. EPA thanks all stakeholders who participated and provided feedback and welcomes additional comments on the changes outlined below.

Please note that significant changes are proposed for the network connections used in the OM and TEC test methods; only one network connection is to be used for the test, and the network connection is specified in Table 6, below. These changes would eliminate at least 57% of OM products from the dataset used during the development of the revised Version 2.0 specification as their energy consumption would be different when measured according to the revised test method. On the other hand, the changes proposed to the TEC test method should affect few products as most were tested using a single Ethernet connection as specified in Table 6.

2 APPLICABILITY

ENERGY STAR test requirements are dependent upon the feature set of the product under evaluation. Table 1 shall be used to determine the applicability of each section of this document:

Table 1: Test Procedure Applicability

Product Type	Media Format	Marking Technology	ENERGY STAR Evaluation Method
Copier	Standard	Direct Thermal (DT), Dye Sublimation (DS), Electro-photographic (EP), Solid Ink (SI), Thermal Transfer (TT)	Typical Energy Consumption (TEC)
	Large	DT, DS, EP, SI, TT	Operational Mode (OM)
Digital Duplicator	Standard	Stencil	TEC
Fax Machine	Standard	DT, DS, EP, SI, TT	TEC
		Ink Jet (IJ)	OM
Mailing Machine	All	DT, EP, IJ, TT	OM
Multifunction Device (MFD)	Standard	High Performance IJ, DT, DS, EP, SI, TT	TEC
		IJ	OM
	Large	DT, DS, EP, IJ, SI, TT	OM
Printer	Standard	High Performance IJ, DT, DS, EP, SI,	TEC

		TT	
		IJ, Impact	OM
	Large or Small	DT, DS, EP, Impact, IJ, SI, TT	OM
Scanner	All	N/A	OM

3 TEST SETUP

A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this procedure shall be in accordance with the requirements of IEC standard 62301, Ed. 2.0, "Measurement of Household Appliance Standby Power", Section 4, "General Conditions for Measurements". In the event of conflicting requirements, the ENERGY STAR test method shall take precedence.

> **Note:** The reference procedure for test setup has been updated to the most recent version of IEC standard 62301 Ed. 2.0.

B) Ac Input Power: Products intended to be powered from an ac mains power source shall be connected to a voltage source appropriate for the intended market, as specified in Table 2 or Table 3.

1) Products shipped with external power supplies (EPSs) shall first be connected to the EPS and then to the voltage source specified in Table 2 or Table 3.

2) If a product is designed to operate at a voltage/frequency combination in a specific market that is different from the voltage/frequency combination for that market (e.g., 230 volts (V), 60 hertz (Hz) in North America), the manufacturer should test the product at the regional combination that most closely matches the product's design capabilities and note this fact on the test reporting sheet.

Table 2: Input Power Requirements for Products with Nameplate Rated Power Less Than or Equal to 1500 W

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 V ac	+/- 1.0 %	2.0 %	60 Hz	+/- 1.0 %
Europe, Australia, New Zealand	230 V ac	+/- 1.0 %	2.0 %	50 Hz	+/- 1.0 %
Japan	100 V ac	+/- 1.0 %	2.0 %	50 Hz/60 Hz	+/- 1.0 %

v) Measurements of accumulated energy should have resolutions which are generally consistent with these values when converted to average power. For accumulated energy measurements, the figure of merit for determining required accuracy is the maximum power value during the measurement period, not the average, since it is the maximum that determines the metering equipment and setup.

G) Measurement Uncertainty: The uncertainty of all measurements conducted under this test method shall meet the requirements of section 4.4.1 of IEC standard 62301, Ed. 2.0.

Note: The section on measurement accuracy was updated to eliminate redundancy by referencing the uncertainty requirements in IEC standard 62301 Ed. 2.0.

H) Time Measurement: Time measurements may be performed with an ordinary stopwatch with resolution of at least 1 second.

I) Paper Specifications:

1) Standard format products shall be tested in accordance with Table 4.

2) Large, Small, and Continuous Format products shall be tested using any compatible paper size.

Table 4: Paper Size and Weight Requirements

Market	Paper Size	Basis Weight (g/m^2)
North America / Taiwan	8.5” x 11”	75
Europe / Australia / New Zealand	A4	80
Japan	A4	64

4 PRE-TEST UUT CONFIGURATION FOR ALL PRODUCTS

4.1 General Configuration

A) Product Speed for Calculations and Reporting: The product speed for all calculations and reporting shall be the highest speed as claimed by the manufacturer per the following criteria, expressed in images per minute (ipm) and rounded to the nearest integer:

1) In general, for Standard-size products, a single A4 or 8.5” x 11” sheet printed/copied/scanned on one side in a minute is equal to one (ipm)

2) For all products, the product speed shall be based on:

i) The manufacturer-claimed print speed, unless the product cannot print, in which case,

ii) The manufacturer-claimed copy speed, unless the product cannot print or copy, in which case,

iii) The manufacturer-claimed scan speed.

3) For non-Continuous Form products, with the exception of mailing machines, the product speed shall be calculated per Table 5. If the maximum claimed speeds differ when producing images on A4 or 8.5” x 11” paper, the higher of the two shall be used.

Table 3: Input Power Requirements for Products with Nameplate Rated Power Greater than 1500 W

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 V ac	+/- 4.0 %	5.0 %	60 Hz	+/- 1.0 %
Europe, Australia, New Zealand	230 V ac	+/- 4.0 %	5.0 %	50 Hz	+/- 1.0 %
Japan	100 V ac	+/- 4.0 %	5.0 %	50 Hz/60 Hz	+/- 1.0 %

C) Low-voltage Dc Input Power:

1) Products may only be powered with a low-voltage dc source (e.g., via network or data connection) if the dc source is the only acceptable source of power for the product (e.g., no ac plug or EPS is included with the product).

2) Products powered by low-voltage dc shall be configured with an ac source of the dc power for testing (e.g., an ac-powered universal serial bus (USB) hub).

3) The power reported for units under test (UUT) requiring low-voltage dc input power shall be equal to the ac power drawn by the dc power source during normal testing minus the ac power drawn by the dc power source with no load applied, as measured in the sections that follow.

i) Connect the dc source to the power meter and relevant ac supply as specified in Table 2 or Table 3.

ii) Verify that the dc source is unloaded.

iii) Allow the dc source to warm up for a minimum of 30 minutes.

iv) Measure and record the unloaded dc source power (P_S) according to section 5.3 of IEC standard 62301 Ed. 2.0.

> **Note:** IEC standard 62301 Ed. 2.0 does not include dc powered products within its scope and notes that the possibility of inclusion is “under consideration”. However, ENERGY STAR believes the power measurement techniques in section 5.3 of the standard are applicable.

D) Ambient Temperature: Ambient temperature shall be 23°C ± 5°C.

E) Relative Humidity: Relative humidity shall be from 10% to 80%.

F) Power Meter: Power meters shall possess the following attributes:

1) Minimum Frequency Response (Recommended): 3.0 kHz

2) Minimum Resolution:

i) 0.01 W for measurement values less than 10 W;

ii) 0.1 W for measurement values from 10 W to 100 W;

iii) 1 W for measurement values from 100 W to 1.5 kW; and

iv) 10 W for measurement values greater than 1.5 kW.

Table 5: Calculation of Product Speed for Standard, Small, and Large Format Products with the Exception of Mailing Machines

Media Format	Media Size	Product Speed, s (ipm) *Where:* *s_P is the maximum claimed monochrome speed in pages per minute when processing the given media*
Standard	8.5" x 11"	s_P
	A4	s_P
Small	4" x 6"	0.25 x s_P
	A6	0.25 x s_P
Large	A2	4 x s_P
	A0	16 x s_P

4) For Continuous Form products, product speed shall be calculated per Equation 1

Equation 1: Calculation of Product Speed

$$s = 16 w s_L$$

Where:

- *s is the product speed, in ipm,*
- *w is the width of the media, in meters (m),*
- *s_L is the maximum claimed monochrome speed, in meters per minute.*

5) For Mailing Machines, product speed shall be reported in units of mail pieces per minute (mppm).

B) Color: Color-capable products shall be tested making monochrome images unless incapable of doing so.

> **Note:** ENERGY STAR has decided not to include color testing in the Test Method due to the limited apparent prevalence of color printing in typical use and its limited impact on energy consumption.

C) Network Connections: Products that are capable of being network-connected as-shipped shall be connected to a network.

1) Products shall be connected to only one network or data connection for the duration of the test.

2) The type of network connection depends on the characteristics of the UUT and shall be the topmost available connection in the appropriate column of Table 6, with the exception of products with 10 Gigabits per second (Gb/s) Ethernet, which shall be tested at 1 Gb/s.

Table 6: Network or Data Connections for Use in Test

Order of Preference for Use in Test (if Provided by UUT)	Connections for Standard-format Ink Jet and Impact Printers and MFDs	Connections for all TEC Products and OM Products Except for Standard-format Ink Jet and Impact Printers and MFDs
1	Ethernet – 1 Gb/s	Ethernet – 1 Gb/s
2	Ethernet – 100 Mb/s	Ethernet – 100 Mb/s
3	Wi-Fi	USB 3.x
4	USB 3.x	USB 2.x
5	USB 2.x	USB 1.x
6	USB 1.x	RS232
7	RS232	IEEE 1284 [1]
8	IEEE 1284	Wi-Fi
9	Other Wired – in order of preference from highest to lowest speed	Other Wired – in order of preference from highest to lowest speed
10	Other Wireless – in order of preference from highest to lowest speed	Other Wireless – in order of preference from highest to lowest speed
11	If none of the above, test with whatever connection is provided by the device (or none)	If none of the above, test with whatever connection is provided by the device (or none)

Note: The above table is intended to balance the requirements of the test method to be reflective of typical use while maintaining uniformity in testing. Specifically, it was assumed that individuals are more likely to use Wi-Fi than commercial users, and though this may not always be the case, testing in a standard fashion will make the tests more repeatable.

Also, since only one interface shall now be active during the test, ENERGY STAR is considering eliminating allowances for functional adders such as data and network connections. Furthermore, ENERGY STAR is also considering eliminating allowances for other functional adders such as hard disk drives and memory. ENERGY STAR welcomes comments on this proposal, and/or updated allowance levels where the adders are to be retained. For a list of updated adder allowances being proposed by EPA, please see the letter to stakeholders distributed along with this draft test method, dated July 8, 2011.

3) Products connected to Ethernet, per paragraph 5.1.C)2) above, and capable of supporting Energy Efficient Ethernet (IEEE Standard 802.3az)[2], shall be connected to a network switch or router that also supports Energy Efficient Ethernet for the duration of the test.

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1 Also referred to as a Parallel or Centronics interface.

2 Institute of Electrical and Electronics Engineers (IEEE) Standard 802.3az-2010. “IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.” 2010.

Note: Since IEEE 802.3az was ratified recently (in September 2010), ENERGY STAR does not expect any currently-qualified products to be affected by this standard and does not expect this change to require any retesting.

4) In all cases the type of connection used during the test shall be reported.

4.2 Configuration for Fax Machines

A) All fax machines and products incorporating fax machines that connect to a telephone line shall be connected to a telephone line during the test.

Note: ENERGY STAR assumes that products purchased with fax capability will be operated with a connection to a telephone line, and should therefore be tested as such. However, ENERGY STAR does not expect this test method change to require any retesting, as during the April 13 webinar partners stated that fax connection should not have an impact on energy consumption

B) Unless sending jobs via phone line, originals may be placed in the document feeder before the test begins.

1) Products without a document feeder may make all images from a single original placed on the platen.

2) Fax machines shall be tested with one image per job.

4.3 Configuration for Digital Duplicators

A) Except as noted below, digital duplicators shall be configured and tested as printers, copiers, or MFDs, depending on their capabilities as shipped.

1) Digital duplicators shall be tested at maximum claimed speed, which is also the speed that should be used to determine the job size for performing the test, not at the default as-shipped speed, if different.

2) For digital duplicators, there shall be only one original image.

5 PRE-TEST UUT INITIALIZATION FOR ALL PRODUCTS

A) Prior to the start of testing, the UUT shall be initialized as follows:

1) Set up the UUT per the instructions in the Manufacturer's Instructions or documentation.

i) Accessories such as paper source and finishing hardware that are intended to be installed or attached by the end-user shall be installed; however, their use in the test is at the manufacturer's discretion (e.g., any paper source may be used).

ii) If the product is connected to a computer during the test, the computer shall be running the manufacturer's default driver using settings corresponding to the default settings upon shipment.

Note: To clarify the test method and promote repeatability, ENERGY STAR decided to clarify that key driver settings used during testing correspond to the defaults upon shipment, regardless of the implementation details of those settings. Based on stakeholder input, ENERGY STAR does not intend to require testing with the same driver as that installed upon shipment. Specifically, ENERGY STAR would like to ensure that any image sent to the UUT via a computer has been processed by the OEM driver using default settings.

2) Connect the UUT to its power source.
3) Power on the UUT and perform initial system configuration, as applicable. Verify that default delay times are configured according to product specifications and/or manufacturer recommendations.
    i) Product Speed for Testing: The product shall be tested with speed settings in their default as-shipped configuration.
    ii) Auto-off for TEC Products: If a printer, digital duplicator, fax machine or MFD with print-capability has Auto-off capability and it is enabled as-shipped, it shall be disabled prior to the test.
    iii) Auto-off for OM Products: If a product has an Auto-off Mode enabled as shipped, it shall be enabled prior to performing the test.
4) User-controllable anti-humidity features shall be turned off or disabled for the duration of testing.
5) Let the UUT sit for at least 15 minutes, or until it has completed initialization and is ready for use.

Note: ENERGY STAR is considering extending initial pre-conditioning time to 2 hours prior to any testing to ensure that all products begin testing with their internal temperature equal to that of the ambient air. ENERGY STAR welcomes stakeholder feedback on the necessity of such a requirement.

6) For products designed to operate on battery power when not connected to the mains power source, the battery shall be either:
    i) Removed from the product; or
    ii) Fully charged for at least 24 hours before beginning the test and left in place for the duration of the test.

6 TYPICAL ELECTRICITY CONSUMPTION (TEC) TEST PROCEDURE

6.1 Job Structure

A) Jobs per Day: The number of jobs per day (N_{JOBS}) is specified in Table 7.

Table 7: Number of Jobs per Day (N_{JOBS})

Monochrome Product Speed, s (ipm)	Jobs per Day (N_{JOBS})
$s \leq 8$	8
$8 < s < 32$	s
$s \geq 32$	32

B) Images per Job:

1) Except for fax machines, the number of images shall be computed according to Equation 2, below. For convenience, Table 11 at the end of this document provides the resultant images per job computation for each integer product speed up through 100 ipm.

Equation 2: Calculation of Number of Images per Job

$$N_{IMAGES} = \text{int}\left[\frac{(0.5 \times s^2)}{N_{JOBS}}\right],$$

Where:

- N_{IMAGES} *is the number of images per job, rounded down (truncated) to the nearest integer,*
- *s is the (monochrome) maximum reported speed in images per minute (ipm), calculated in section 5.1.A), of this test procedure, and*
- N_{JOBS} *is the number of jobs per day, as calculated per Table 7.*

Note: ENERGY STAR has decided not to modify the usage assumptions integrated into the TEC test procedure (i.e., the number of images per job, and the number of jobs per day) due to a lack of data indicating a more representative usage pattern.

C) Test Image: Test Pattern A from ISO/IEC standard 10561:1999 shall be used as the original image for all testing.

1) Test images shall be rendered in 10 point size in a fixed-width Courier font (or nearest equivalent).

2) German-specific characters need not be reproduced if the product is incapable of German character reproduction.

Note: As mentioned above, ENERGY STAR has decided not to include color testing in the Test Method due to the limited apparent prevalence of color printing in typical use and its limited impact on energy consumption.

D) Print Jobs: Print jobs for the test may be sent over non-network connections (e.g., USB), even on those units that are network-connected.

1) Each image in a print job shall be sent separately, i.e., all images may be part of the same document, but shall not be specified in the document as multiple copies of a single original image (unless the product is a digital duplicator).

2) For printers and MFDs that can interpret a page description language (PDL) (e.g., PCL, Postscript), images shall be sent to the product in a PDL.

E) Copy Jobs:

1) For copiers with speed less than or equal to 20 ipm, there shall be one original per required image.

2) For copiers with speed greater than 20 ipm, it may not be possible to match the number of required original images (e.g., due to limits on document feeder capacity). In this case, it is permissible to make multiple copies of each original, and the number of originals shall be greater than or equal to ten.

Example: For a 50 ipm unit that requires 39 images per job, the test may be performed with four copies of 10 originals or three copies of 13 originals.

3) Originals may be placed in the document feeder before the test begins.

i) Products without a document feeder may make all images from a single original placed on the platen.

6.2 Measurement Procedures

A) Measurement of TEC shall be conducted according to Table 8 for printers, fax machines, digital duplicators with print capability, and MFDs with print capability, and Table 9 for copiers, digital duplicators without print capability and MFDs without print capability, subject to the following provisions:

1) Paper: There shall be sufficient paper in the UUT to perform the specified print or copy jobs.

2) Duplexing: Products shall be tested in simplex mode, unless the speed of duplex mode output is greater than the speed of simplex mode output, in which case they shall be tested in duplex mode. Originals for copying shall be simplex images.

i) Manufacturers that wish to have units tested in duplex must provide a rated speed for the unit in duplex mode.

ii) For all products tested, the product speed and the mode in which it was tested will be recorded.

3) Service/Maintenance Modes: Service/maintenance modes (including color calibration) should not be included in TEC measurements.

i) Any service/maintenance modes that occur during the test shall be noted.

ii) If a service/maintenance mode occurs during a job other than the first job, the results from the job with the service/maintenance mode may be replaced with results from a substitute job. In this case, the substitute job shall be inserted into the test procedure immediately following Job 4. The 15 minute job interval shall be maintained at all times.

Note: The previously specified accuracy requirements have been removed as they were redundant with those in section 4 (Test Setup), above. All requirements have been updated to be harmonized with IEC standard 62301 Ed. 2.0.

4) Energy Measurement Method: All measurements shall be recorded as accumulated energy over time, in Wh; all time shall be recorded in minutes.

i) "Zero meter" references may be accomplished by recording the accumulated energy consumption at that time rather than literally zeroing the meter.

Table 8: TEC Test Procedure for Printers, Fax Machines, Digital Duplicators with Print Capability, and MFDs with Print Capability

Step	Initial State	Action	Record (at end of step)	Unit of Measure	Possible States Measured
1	Off	Connect the unit under test to the meter. Ensure the unit is powered and in Off Mode. Zero the meter; measure energy over 5 minutes or more. Record both energy and time.	Off energy Testing Interval time	Watt-hours (Wh) Minutes (min)	Off
2	Off	Turn on unit. Wait until unit indicates it is in Ready Mode.	–	–	–
3	Ready	Print a job of at least one output image but no more than a single job per Job Table. Measure and record time to first sheet exiting unit.	Active0 time	Minutes (min)	–
4	Ready (or other)	Wait until the meter shows that the unit has entered its final Sleep Mode or the time specified by the manufacturer.	–	–	–
5	Sleep	Zero meter; measure energy and time over 1 hour. Record the energy and time.	Sleep energy, E_{SLEEP} Sleep time, t_{SLEEP} (≤ 1 hour)	Watt-hours (Wh) Minutes (min)	Sleep
6	Sleep	Zero meter and timer. Print one job (calculated above). Measure energy and time. Record time to first sheet exiting unit. Measure energy over 15 minutes from job initiation. The job must finish within the 15 minutes.	Job1 energy, E_{JOB1} Active1 time	Watt-hours (Wh) Minutes (min)	Recovery, Active, Ready, Sleep
7	Ready (or other)	Repeat Step 6.	Job2 energy, E_{JOB2} Active2 time	Watt-hours (Wh) Minutes (min)	Same as above
8	Ready (or other)	Repeat Step 6 (without Active time measurement).	Job3 energy, E_{JOB3}	Watt-hours (Wh)	Same as above
9	Ready (or other)	Repeat Step 6 (without Active time measurement).	Job4 energy, E_{JOB4}	Watt-hours (Wh)	Same as above
10	Ready (or other)	Zero meter and timer. Measure energy and time until meter and/or unit shows that unit has entered Sleep Mode or the final Sleep Mode for units with multiple Sleep modes, or the time specified by the manufacturer.	Final energy, E_{FINAL} Final time, t_{FINAL}	Watt-hours (Wh) Minutes (min)	Ready, Sleep

Table 9: TEC Test Procedure for Copiers, Digital Duplicators without Print Capability, and MFDs without Print Capability

Step	Initial State	Action	Record	Unit of Measure	Possible States Measured
1	Off	Connect the unit under test to the meter. Ensure the unit is powered and in Off Mode. Zero the meter; measure energy over 5 minutes or more. Record both energy and time.	Off energy	Watt-hours (Wh)	Off
			Testing Interval time	Minutes (min)	
2	Off	Turn on unit. Wait until unit has entered Ready Mode.	–	–	–
3	Ready	Copy a job of at least one image but no more than a single job per Job Table. Measure and record time to first sheet exiting unit	Active0 time	Minutes (min)	–
4	Ready (or other)	Wait until the meter shows that the unit has entered its final Sleep Mode or the time specified by the manufacturer.	–	–	–
5	Sleep	Zero meter; measure energy and time over 1 hour or until unit enters Auto-off Mode. Record the energy and time.	Sleep energy	Watt-hours (Wh)	Sleep
			Sleep time (≤ 1 hour)	Minutes (min)	
6	Sleep	Zero meter and timer. Copy one job (calculated above). Measure and record energy and time to first sheet exiting unit. Measure energy over 15 minutes from job initiation. The job must finish within the 15 minutes.	Job1 energy, E_{JOB1}	Watt-hours (Wh)	Recovery, Active, Ready, Sleep, Auto-off
			Active1 time	Minutes (min)	
7	Ready (or other)	Repeat Step 6.	Job2 energy, E_{JOB2}	Minutes (min)	Same as above
			Active2 time	Watt-hours (Wh)	
8	Ready (or other)	Repeat Step 6 (without Active time measurement).	Job3 energy, E_{JOB3}	Watt-hours (Wh)	Same as above
9	Ready (or other)	Repeat Step 6 (without Active time measurement).	Job4 energy, E_{JOB4}	Watt-hours (Wh)	Same as above
10	Ready (or other)	Zero meter and timer. Measure energy and time until meter and/or unit shows that unit has entered its Auto-off Mode or the time specified by the manufacturer. Record energy and time; if unit began this step already in Auto-off Mode, report both energy and time values as zero.	Final energy, E_{FINAL}	Watt-hours (Wh)	Ready, Sleep
			Final time, t_{FINAL}	Minutes (min)	
11	Auto-off	Zero the meter; measure energy and time over 5 minutes or more. Record both energy and time.	Auto-off energy, E_{AUTO}	Watt-hours (Wh)	Auto-off
			Auto-off time, t_{AUTO}	Minutes (min)	

Note:

1) Because there is a lack of specific product examples with a power buffer, ENERGY STAR does not intend to modify the test method to require recording energy consumed during Step 2 of the TEC measurement.

2) ENERGY STAR has clarified the TEC test method in Table 8 and Table 9 above, and will clarify the reporting requirements to indicate that the duration of time until the UUT has reached its final sleep or auto-off mode shall be specified by the manufacturer. This change will remove potential testing ambiguity by specifying how long testers must wait before concluding measurement in those modes.

7 OPERATIONAL MODE (OM) TEST PROCEDURE

7.1 Measurement Procedures

A) Measurement of OM power and delay times shall be conducted according to Table 10, subject to the following provisions:

   1) All power figures shall be recorded in W in accordance with section 5.3 of IEC standard 62301 Ed. 2.0, unless otherwise specified in this document.

Note: The previously-specified accuracy requirements have been removed as they were redundant with those in section 4 (Test Setup), above. All requirements have been updated to be harmonized with IEC standard 62301 Ed. 2.0

   2) Service/Maintenance Modes: Service/maintenance modes (including color calibration) should not be included in measurements. Any adaptation of the procedure needed to exclude such modes that occur during the test shall be noted.

Table 10: Operational Mode (OM) Test Procedure

Step	Initial State	Action(s)	Record	Unit of Measure
1	Off	Plug the unit into meter. Turn on unit. Wait until unit indicates it is in Ready Mode.	–	
2	Ready	Print, copy, or scan a single image.	–	
3	Ready	Measure Ready power.	Ready power, P_{READY}	Watts (W)
4	Ready	Wait and measure default delay-time to Sleep.	Sleep default-delay time, t_{SLEEP}	Minutes (min)
5	Sleep	Measure Sleep power.	Sleep power, P_{SLEEP}	Watts (W)
6	Sleep	Wait and measure default delay time to Auto-off. (Disregard if no Auto-off Mode)	Auto-off default-delay time	Minutes (min)
7	Auto-off	Measure Auto-off power. (Disregard if no Auto-off Mode)	Auto-off power $P_{AUTO-OFF}$	Watts (W)
8	Auto-off	Manually turn device off and wait until unit is off. (If no manual on-off switch, note and wait for lowest-power Sleep state).	–	–
9	Off	Measure Off power. (If no manual on-off switch, note and measure Sleep Mode power).	Off power P_{OFF}	Watts (W)

Notes:

- *Step 1 – If the unit has no Ready indicator, use the time at which the power consumption level stabilizes to the Ready level, and note this detail when reporting the product test data.*
- *Steps 4 and 5 – For products with more than one Sleep level, repeat these steps as many times as necessary to capture all successive Sleep levels and report these data. Two Sleep levels are typically used in large-format copiers and MFDs that use high-heat marking technologies. For products lacking this Mode, disregard Steps 4 and 5.*
- *Steps 4 and 6 – Default-delay time measurements are to be measured in parallel fashion, cumulative from the start of Step 4. For example, a product set to enter a Sleep level in 15 minutes and enter a second Sleep level 30 minutes after entering the first Sleep level will have a 15-minute default-delay time to the first level and a 45 minute default-delay time to the second level.*

8 TEST PROCEDURES FOR PRODUCTS WITH A DIGITAL FRONT END (DFE)

This step applies only to products that have a DFE as defined in Section 1 of the ENERGY STAR Program Requirements for Imaging Equipment.

> **Note**: ENERGY STAR intends to incentivize energy efficiency of imaging products with DFEs by measuring the energy consumption of the DFE in the modes that are most prevalent: Ready and Sleep. This change will require retesting of all imaging equipment units with DFEs.
>
> Following retesting, the energy savings potential of DFE energy consumption requirements will be analyzed and DFE energy consumption requirements may be proposed for discussion during the specification development process.

A) If the DFE has a separate main power cord, regardless of whether the cord and controller are internal or external to the imaging product, a five-minute energy measurement of the DFE alone shall be made while the main product is in Ready Mode. The unit must be connected to a network if shipped as network-capable.

B) If the DFE does not have a separate main power cord, the manufacturer shall measure the dc power required for the DFE when the unit as a whole is in a Ready Mode. This will most commonly be accomplished by taking an instantaneous power measurement of the dc input to the DFE.

> **Note**: ENERGY STAR is proposing to require that manufacturers directly report the dc power to the DFE without adjusting for any power supply inefficiency as such adjustments are likely to be unreliable without knowing the efficiency curve of the power supply used for the test.

C) Repeat either of the above measurements, which depend on the DFE Type, while the imaging product is in its final sleep mode and record the DFE power.

9 REFERENCES

A) ISO/IEC 10561:1999. Information technology — Office equipment — Printing devices — Method for measuring throughput — Class 1 and Class 2 printers.

B) IEC 62301:2011. Household Electrical Appliances – Measurement of Standby Power. Ed. 2.0.

Table 11: Number of Images per Day Calculated for Product Speeds from 1 to 100 ipm.

Speed	Jobs/ Day	Interim Images/ Day	Interim Images/ Job	Images/ Job	Images/ Day	Speed	Jobs/ Day	Interim Images/ Day	Interim Images/ Job	Images/ Job	Images/ Day
1	8	1	0.06	**1**	8	51	32	1301	40.64	**40**	1280
2	8	2	0.25	**1**	8	52	32	1352	42.25	**42**	1344
3	8	5	0.56	**1**	8	53	32	1405	43.89	**43**	1376
4	8	8	1.00	**1**	8	54	32	1458	45.56	**45**	1440
5	8	13	1.56	**1**	8	55	32	1513	47.27	**47**	1504
6	8	18	2.25	**2**	16	56	32	1568	49.00	**49**	1568
7	8	25	3.06	**3**	24	57	32	1625	50.77	**50**	1600
8	8	32	4.00	**4**	32	58	32	1682	52.56	**52**	1664
9	9	41	4.50	**4**	36	59	32	1741	54.39	**54**	1728
10	10	50	5.00	**5**	50	60	32	1800	56.25	**56**	1792
11	11	61	5.50	**5**	55	61	32	1861	58.14	**58**	1856
12	12	72	6.00	**6**	72	62	32	1922	60.06	**60**	1920
13	13	85	6.50	**6**	78	63	32	1985	62.02	**62**	1984
14	14	98	7.00	**7**	98	64	32	2048	64.00	**64**	2048
15	15	113	7.50	**7**	105	65	32	2113	66.02	**66**	2112
16	16	128	8.00	**8**	128	66	32	2178	68.06	**68**	2176
17	17	145	8.50	**8**	136	67	32	2245	70.14	**70**	2240
18	18	162	9.00	**9**	162	68	32	2312	72.25	**72**	2304
19	19	181	9.50	**9**	171	69	32	2381	74.39	**74**	2368
20	20	200	10.00	**10**	200	70	32	2450	76.56	**76**	2432
21	21	221	10.50	**10**	210	71	32	2521	78.77	**78**	2496
22	22	242	11.00	**11**	242	72	32	2592	81.00	**81**	2592
23	23	265	11.50	**11**	253	73	32	2665	83.27	**83**	2656
24	24	288	12.00	**12**	288	74	32	2738	85.56	**85**	2720
25	25	313	12.50	**12**	300	75	32	2813	87.89	**87**	2784
26	26	338	13.00	**13**	338	76	32	2888	90.25	**90**	2880
27	27	365	13.50	**13**	351	77	32	2965	92.64	**92**	2944
28	28	392	14.00	**14**	392	78	32	3042	95.06	**95**	3040
29	29	421	14.50	**14**	406	79	32	3121	97.52	**97**	3104
30	30	450	15.00	**15**	450	80	32	3200	100.00	**100**	3200
31	31	481	15.50	**15**	465	81	32	3281	102.52	**102**	3264
32	32	512	16.00	**16**	512	82	32	3362	105.06	**105**	3360
33	32	545	17.02	**17**	544	83	32	3445	107.64	**107**	3424
34	32	578	18.06	**18**	576	84	32	3528	110.25	**110**	3520
35	32	613	19.14	**19**	608	85	32	3613	112.89	**112**	3584
36	32	648	20.25	**20**	640	86	32	3698	115.56	**115**	3680
37	32	685	21.39	**21**	672	87	32	3785	118.27	**118**	3776
38	32	722	22.56	**22**	704	88	32	3872	121.00	**121**	3872
39	32	761	23.77	**23**	736	89	32	3961	123.77	**123**	3936
40	32	800	25.00	**25**	800	90	32	4050	126.56	**126**	4032
41	32	841	26.27	**26**	832	91	32	4141	129.39	**129**	4128
42	32	882	27.56	**27**	864	92	32	4232	132.25	**132**	4224
43	32	925	28.89	**28**	896	93	32	4325	135.14	**135**	4320
44	32	968	30.25	**30**	960	94	32	4418	138.06	**138**	4416
45	32	1013	31.64	**31**	992	95	32	4513	141.02	**141**	4512
46	32	1058	33.06	**33**	1056	96	32	4608	144.00	**144**	4608
47	32	1105	34.52	**34**	1088	97	32	4705	147.02	**147**	4704
48	32	1152	36.00	**36**	1152	98	32	4802	150.06	**150**	4800
49	32	1201	37.52	**37**	1184	99	32	4901	153.14	**153**	4896
50	32	1250	39.06	**39**	1248	100	32	5000	156.25	**156**	4992

10 APPENDIX A: TEST REPORTING TEMPLATE

Laboratory Information	
Laboratory Name	
Address	
Test Office	
Dates Test Conducted	

Product Description	
Product Type	
Media Format	
Marking Technology	
Product Brand	
Model Name (if available)	
Model Number	
Default Delay Time to Sleep Mode	
Rated Voltage	
Image Speed (ipm, ppm)	

Test Results (to be completed for each unique test)	
Standby Energy (Wh)	
Ready Mode Energy (Wh)	
Time to Ready Mode (min)	
Time to Sleep Mode (min)	
Sleep Energy, E_{SLEEP} (Wh)	
Sleep Time, t_{SLEEP} (min)	
Job1 Energy, E_{JOB1} (Wh)	
Recovery Time (min)	
Job2 Energy, E_{JOB2} (Wh)	
Active1 Time, $t_{ACTIVE1}$ (min)	
Job3 Energy, E_{JOB3} (Wh)	
Job4 Energy, E_{JOB4} (Wh)	
Final Energy, E_{FINAL} (Wh)	
Final Time, t_{FINAL} (min)	

6.3 Indication of the best 10-20 % performing energy efficient imaging equipment devices (excerpt from the discussion Sub-AHWG).

IPPS presented for discussion to the AHWG sub-group for energy an indication of the best performing 10-20 % imaging equipment devices based on energy efficiency. This proposal was adopted by the energy sub-AHWG and will be forwarded to the Energy Star developers of version 2.0 for imaging equipment.

<u>Objective and scope:</u> In the process of developing Ecolabel and Green Public Procurement criteria, one of the criteria areas is energy efficiency during the use phase. The aim of this calculation is to get an indication of the ambition level for determining requirements level which could fulfil the needs of Ecolabel and GPP. The rationale of this calculation should serve as input for the discussion of the energy expert group.

<u>Background References:</u>

1. EU Ecolabel Regulation 66/2010,
2. Industry Voluntary Agreement to improve the environmental performance of imaging equipment placed on the European market, version 3.5, February 2011.

<u>Input and Assumptions:</u>

1. *The draft criteria shall comply with the following requirement: "they shall be based on the best products available on the Community market in terms of environmental performance throughout the life cycle, and they shall correspond indicatively to the best 10-20 % of the products available on the Community market in terms of environmental performance at the moment of their adoption".*
   Source: Ecolabel Regulation 66/2010.

2. *By 1 January 2012: 90 % or more of the products placed by a Signatory on the EU market will meet the specifications of Energy Star v1.1.*
   Source: Industry Voluntary Agreement for imaging equipment v. 3.5

3. *Assumption: The Energy Star label is a very successful label. All the products that fulfil the requirements of Energy Star 1.1 bear the Energy Star label.*

Rationale of calculation:

If 90 % of the products in the EU market fulfil the Energy Star 1.1 performance requirements then the best 20 % per category of the Energy Star 1.1 registered products will represent 18 % best performing products on the overall market.

Needs of EU Ecolabel:

Based on the 66/2010 Regulation, the criteria of the EU Ecolabel shall correspond to the best 10-20 % of products in term of environmental performance. However, to what extent each criterion corresponds to the above percentage range is not strictly determined. The percentage range refers to the product market share when all the criteria are applied. This allows for certain flexibility in setting the benchmarks for each criterion.

Proposal:

Based on the above rationale it is possible to estimate energy efficiency levels for the individual imaging equipment devices as classified in Energy Star 1.1 which meet the requirements of the future EU Ecolabel.

From the point of view of IPTS it is desirable to discuss these potential EU Ecolabel levels with US Energy Star developers in order to support their ongoing development, as the Energy Star 2.0 requirements are intended to arrive at similar efficiency performance levels.

6.4 Additional information on noise emissions criteria

Noise emissions are rated by the declared A-weighted sound power level. Following the ISO 80000-8 it is clearly given that: "*In practical applications and consistent with the definition of sound pressure [power, exposure] level, the sub multiple decibel, dB, is used instead of the bel, B.*" This gives reasons for using the noise emissions limits based on dB.

<u>Measurement and calculation of sound power and printing speed:</u>

The A-weighted sound power level L_{WA} shall be determined according to ISO 7779:2010 (corresponds to ECMA-74:2010). Noise measurements shall be conducted with products in standard product configuration without optional peripheral devices (e.g. sorters, stackers, staplers, binders or cutters) at operating temperature.

Devices of identical design which differ in their maximum (attainable) printing speeds shall be tested in all configurations in which they are to be offered, with reference to the EU Ecolabel.

- A-4 size paper with paper weights between 60 to 80 g/m² shall be used for printouts;
- The test document according to image C.5 b) of ECMA-74:2010 shall serve as test page for monochrome as well as for colour printing or copying;
- Devices capable of multiple colour printing shall additionally be tested in full colour mode in the same way as described for monochrome printing.

The following specific requirements differ from ISO 7779:2010 (ECMA-74:2010) and shall be taken into account in the testing process:

- Noise measurements shall be conducted during maximum noise operation of the base unit (usually at maximum print speed);
- The measured values are time-averaged over the measurement time interval;
- The L_{WA} of ink-jet devices shall be determined in standard printout mode (usually preset).

<u>Printers:</u>

- One-sided printing shall be measured unless two-sided printing is the default mode, in which case two-sided printing shall be measured;
- The measurement time interval starts at the beginning of printing (including preparation of printing, e.g. paper loading and positioning of the print heads) and ends after the output of the sixth page of the test document.

<u>Copiers and MFD:</u>

- One-sided printing shall be measured. L_{WA} shall be conducted during scanning via the flat-bed scanner or ADF (if standard product configuration) and printing of six copies of the test document;
- The measurement time interval starts at the beginning of the scanning process and ends after the output of the sixth page of the test document. Pauses of more than three seconds between the end of the scanning process and the beginning of the printing process shall not be included in the averaging.

The measurement of printing speeds S_{bw} und S_{co} in pages per minute shall be conducted under the same operating conditions as they are set for noise measurements. The number of printouts shall be counted from the beginning of the first printout for one minute duration. Only fully completed printouts shall be counted.

- S_{bw} = operating speed for monochrome printing in pages per minute;
- S_{co} = operating speed for colour printing in pages per minute.

Declared sound power level

At least three devices have to be tested in order for the sound power level to be considered as declared. The declared sound power level L_{WAd} shall be determined following the procedures of ISO 9296:1988 and shall be declared in decibels (dB) with one decimal place. If the noise emission measurement can be performed on one device only, the following formula may be used as a substitute to determine the declared A-weighted sound power level L_{WAd}.

$$L_{WAd} = L_{WAE} + 3.0 \text{ dB}$$

(L_{WAE} = sound power level determined by single measurement in dB)

For information on noise emission the L_{WAd} value measured and calculated accurate to 0.1 dB shall be indicated in the user documents (User Manual/Product Documents).

The following limits are proposed:

The devices shall generally not exceed an L_{WAd} 75.0 dB (noise limit for office equipment);

In addition, the declared A-weighted sound power level L_{WAd} shall not exceed the following limits of $L_{WAd,lim,bw}$ or $L_{WAd,lim,co}$ in the respective printout mode:

The limit value $L_{WAd,lim,bw}$ or monochrome printing shall be determined depending on the operating speed S_{bw} given to one decimal place according to the following formula:

$$L_{WAd,lim,bw} = 37+20*\log(S_{bw}+8) \text{ dB}$$

$L_{WAd,lim,bw}$ = A-weighted sound power level limit in dB for monochrome printouts

Accordingly, the following applies to the limit $L_{WAd,lim,co}$ for colour printing on parallel systems:

$L_{WAd,lim,co}$ = (38 + 20*log(S_{co}+8) dB

$L_{WAd,lim,co}$ = -weighted sound power level limit in dB for colour printouts

For serial electrophotographic colour devices with **$S_{co} \leq 0,5\ S_{bw}$,** the sound power level shall be determined and indicated. For assessment purposes, compliance with $L_{WAd,lim,bw}$ for monochrome printouts with printing speed **S_{bw}** shall be considered exclusively.

The following user information is proposed for devices with L_{WAd} > 63.0 dB in monochrome mode:

"Office equipment with L_{WAd} > 63.0 dB is not suitable for the use in rooms where people do primarily intellectual work. Such equipment should be placed in separate rooms because of high noise emission."

Blue Angel additional criterion on noise emissions

In Blue Angel label for imaging equipment is planned (the finalisation of the new Blue Angel criteria will take place in December 2010) to include an additional measurement and declaration of sound power and printing speed. A short presentation of the requirements of Blue Angel criterion follows.

Blue Angel Criterion on Reporting of sound power and printing speed:

"The determination of sound power and printing speed shall be conducted with the use of the test documents and the performance measurement procedure of ISO 24734:2009 (for printers) and ISO 24735:2009 (for copiers and MFD) as follows

Separate measurement protocol for inventory of sound power and printing speed values with usage of ISO 24734:2009 (for printers) and ISO 24735:2009 (for copiers and MFD)

		$ESAT_{30sec}$ [ipm]	$EFTP_{30sec}$ [ipm]	L_{WAd} [dB]
monochrome	simplex			
	duplex			
colour	simplex			
	duplex			

The determination of sound power and printing speed in Blue Angel shall be also conducted with the use of the test documents and one performance measurement procedure of ISO 24734:2009 (for printers) and ISO 24735:2009 (for copiers and MFD).

The procedure shall be similar to those described under noise emissions, only the following adjustments shall be followed:

- The 4-page Adobe Reader file from the Office Test Suite according to B.1 of ISO 24734:2009 shall serve as test page for monochrome as well as for colour printing or copying.

Printers:

- The determination of printing speeds ($ESAT_{30sec}$ und $EFTP_{30sec}$) shall be conducted according to the "1 Set + 30 Seconds Test" in paragraph 5.1.2 of ISO 24734:2009.
- During this printing process, the sound power level shall be conducted according to ISO 7779:2010. The measurement time interval for the time-averaging of L_{WA} shall be from t_1 till t_n according to paragraph 5.1.2 of ISO 24734:2009.

Copiers and MFD:

- The determination of copying speeds ($ESAT_{30sec}$ und $EFTP_{30sec}$) shall be conducted according to the "1 Set + 30 Seconds Test" in paragraph 6.1.2 of ISO 24735:2009.
- During this copying process, the sound power level shall be conducted according to ISO 7779:2010. The measurement time interval for the time-averaging of L_{WA} shall be from t_1 till t_n according to paragraph 6.1.2 of ISO 24735:2009.

The declared sound power level L_{WAd} shall be conducted according to the procedure described under Noise emissions.

There are no sound power level limits. The values of sound power level and printing speed shall be recorded in a separate measurement protocol.

The rationale of this Blue Angel criterion is: "harmonisation with international standards shall be achieved with the adjustment of the noise rating procedure as a part of the future developments of this basic criteria document. Therefore it is proposed that the applicant shall provide additional values which are determined according to international standards".

6.5 Information for removal of Mercury from fluorescent lamps[58]

Currently there are two methods for removing mercury from fluorescent lamps. One method is to cut the end off the tube and remove the mercury and phosphor powder, and the second is to shred the light bulb completely and then mechanically separate out the powder.

An established technique for re-processing fluorescent tubes involves breaking the tube into waste fractions and then extracting the mercury. The process is done in two stages:

1. The fluorescent tubes are crushed, sieved and separated producing a fluorescent powder, glass and metal. The powder is heated under vacuum while simultaneously supplying oxygen to the afterburner. Through varying the vacuum pressure mercury can be extracted from the powder and collected in condensers. Approximately 99 % of the mercury can be recovered,

2. Alternatively size reduction equipment techniques can be used. These operate by crushing the tubes, while a filter traps the mercury vapour that can then be either disposed of or sent for recycling. The mercury can be sold back into industry for use in products such as barometers, thermometers etc. The glass is used to make other glass products such as containers and the end pieces (normally consisting of either brass or aluminium) of the tubes are sold on to scrap metal merchants to be reprocessed.

[58] Huisman, Jaco, Delgado Clara, Magalini Federico, Kuehr Ruediger, Maurer, Claudia Artim, Eniko Szlezak, Josef Ogilvie, Poll Jim, Steve Abs, final Report for DG ENV, 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE), United Nations University, 2008.

6.6 Additional information regarding bioavailability

A respective excerpt of the European chemical Agency, "Guidance on the Application of the CLP Criteria is presented below.

Human health hazards

The assumption is that all substances and mixtures are considered to be bioavailable to some extent. However, there are a few specific cases in which bioavailability may have an influence on hazard classification. For instance in the case of some metals and polymers, the nature of the physical form (metals in solid form) and the molecular size (polymers are very large molecules), or their physical-chemical properties may limit absorption. Where a supplier proposes derogation from hazard classification on the basis of bioavailability, he has to provide adequate and robust data to support the conclusion of lack of bioavailability. It is possible that a substance is bioavailable by one route but not another (e.g. absorbed following inhalation but not absorbed through the skin). In such cases the lack of bioavailability may derogate classification for the relevant route.

Information on relative bioavailability (e.g. relative amounts of absorption) within a related group/category of chemicals can be of some use in classification. It is possible that consideration of bioavailability data in a semi-quantitative manner would lead to the classification for the same hazard class but in a different category on the grounds that the extent of bioavailability would be reflected in the relative potency. In general, a prediction of lower bioavailability must be supported by robust evidence and a weight of evidence determination using expert judgment shall be applied.

Information on bioavailability is usually obtained from adequate, reliable, and conclusive toxicokinetic studies for all relevant routes of exposure and all relevant forms or physical states where the substance and/or metabolite(s) of the substance have been quantified in body fluids and/or target organs. It should be noted that concluding that there is lack of or reduced bioavailability has a high burden of evidence and needs to be supported by robust data and expert evaluation.

Bioavailability of a substance or a mixture is normally assumed if there are in vitro studies available which show the solubility of a substance or mixture in body fluids or artificial simulated body fluids. Furthermore, conclusions on bioavailability of a substance or a Mixture may be based on considerations of the physical properties of a substance or derived from Structural Activity Relationships (SAR). In certain exceptional circumstances it may be possible that a substance on its own or in a mixture can be considered to be non-bioavailable, based on either appropriate *in vitro* data, e.g. from skin absorption models, SAR considerations or considering the physical properties of a substance, if the respective requirements described above have been taken into account in an adequate analysis.

Environmental hazards

The hazard classification for the aquatic environment is based on the three elements aquatic toxicity, bioaccumulation and degradation. The measurement of toxicity to aquatic organisms and its use within a hazard classification system introduces a number of compounding problems. The substance is not dosed directly into the organism but rather into water in which the organism lives. While this reflects more accurately the manner in which the organism will receive the dose in the environment, it does not allow the direct control of the dose which is an important part of much mammalian toxicity testing. The dose is limited by the bioavailability of the substance, the maximum dose being determined by the level of water solubility.

It is usually assumed that toxic effects are only measured following exposure to the dissolved fraction, i.e. organisms are exposed to substances dissolved in water. It is assumed that the substances will either be absorbed by the organisms through passive diffusion or taken up actively by a specific mechanism. Bioavailability may, therefore, vary between different organisms. In the case of bioaccumulation oral exposure could also be considered for substances with high Log K_{ow}.

In general, there are no specific environmental test methods developed to measure biological availability of substances or mixtures. This aspect is built into the testing methodology for toxicity and if adverse effects are identified the substance should be classified accordingly. Substances which lack bioavailability would not be absorbed by the exposed organisms and therefore due to lack of toxic effects these substances would not be classified, unless they are known to degrade or transform to hazardous products. For example see the strategy for metals classification.

6.7 Checklist for recyclable design

A: Structure and Connection Technology

	Components made of materials incompatible with each other are connected separably or via separation aids	Case parts, chassis, electric modules, toner modules	M	☐

Important connections are those between case and chassis as well as those between chassis and electric modules. Their separability is a prerequisite for separate use/recycling of modules and materials as well as for a quick and save separation of pollutant-containing components. Adhesive labels (e.g. company logos and labels) are concerned as well.
The term "separation aids" stands, for example, for predetermined breaking points.

	Electric modules are easily traceable and removable	Entire unit, including lamps	M	☐

Minimum recycling strategy means: removal of the pollutant freight.
Electric modules and components according to Annex III, ElektroG (Electrical and Electronic Equipment Act), as, for example, batteries and condensers involving the risk of pollutant-containing ingredients as well as mercury-containing fluorescent lamps must be easily traceable and separable.

	Disassembly can be done with universal tools exclusively	Case, chassis, electric modules	M	☐

"The term „universal tool“ stands for general commercial tools.

	Necessary points of application and working space for disassembly tools have been taken into consideration	Case parts, chassis, electric modules	M	☐

A point of application is the point from where the impact is transferred from tool to connecting element. Sufficient working space is needed for the execution of the tool's separating movement.
This requirement particularly refers to snap connections which, unlike during assembly, often require tools to be disconnected.

	Screwed connections between modules can be separated with no more than three tools	Case parts, chassis, electric modules	M	☐

Standardized and uniform connection elements facilitate disassembly. The less tools must be changed the easier is assembly and disassembly.
A tool is characterized by the type of drive (e.g. cross recession) and the drive size (spanner size).

	Disassembly can be done by a single person	Entire unit	M	☐

An optional number of snap connections of the same joining direction may be assembled at a time but not always be disassembled if the re-entrant angle is ≥ 90°. This requirement shall be considered not fulfilled if more than two connections must be separated at a time.

	Case parts are free from electronic modules	Case parts	M	☐

With regard to a clean and quick pollutant removal and separation of the electronic parts all electric modules must be connected to the chassis. The case may not contain any electronic modules. Here, a control element attached to the case and case parts which simultaneously perform the functions of the chassis are not considered as case parts.

	The manufacturer did a trial disassembly (e.g. according to A.1 - A.11) and prepared a test report focussing on the weak-points	Entire unit	M	☐

B: Selection and Marking of Materials

	The variety of materials forming plastic components performing comparable functions are limited to one material	Case parts, chassis mechanical parts (≥ 25g)	M	☐

The smaller the number of materials the more efficient are separation and recycling processes. This requirement shall not apply to parts that have been reused as can be proved.

	The coating of plastic components has been limited to the minimum necessary	Case parts, toner and ink modules	M	☐

Large-area layers of lacquer, vapour depositions and printings on plastic components require additional removal processes if recycling by the material is to be done thereafter. Reasons shall be given if metallic coatings are used. Laser-produced labelings shall not be considered as printings. This requirement shall not apply to parts case that have been reused, as can be proved.

	The materials and material compounds used can be recycled by the material	Case parts, chassis, toner modules	M	☐

This means that recyclate materials identical to the original material (original recycling) can be obtained.

	The proportional use of recyclate material is permitted	Case parts, chassis, toner and ink modules	M	☐

A real "cycle" does not exist before the manufacturer actually uses recyclate goods or promises to do so along with the product specification.

	Components and materials under Annex III to ElektroG (Electrical and Electronic Equipment Act) can be easily exchanged	Entire unit	M	☐

	Material selection according to B.1-B.5 has been done and recorded in writing	Case parts, chassis, toner modules	M	☐

	Plastic parts > 25 g according to EN/ ISO 11469: considering ISO 1043 are marked	Entire unit	M	☐

Plastics marking enables all recycling companies to do a type-specific sorting and separation of plastics

C: Longevity

	At least 50% of the components of the device, except for standard parts, are identical in design to those in other devices of the same manufacturer and the same performance category and generation	Entire unit	M	☐

	The use of reprocessed modules or components is possible and permissible	Entire unit	M	☐

The manufacturer shall be prepared to use modules and components as spare parts or ETN-parts in the product, provided that they have been reprocessed under his guidance - (ETN- equivalent to new)

	Toner or ink modules can be reprocessed	Toner and ink modules, except for containers	M	☐

Reuse should not be prevented by constructive measures

All Requirements have been met and answered „Yes“?	M	☐

Place:
Date:

Applicant:
(Signature of authorized representative and company stamp)

6.8 Information on potential substitutes for phthalates used as plasticisers

There are many families of plasticisers. Most common plasticisers are phthalates. However, numerous phthalate plasticisers are regulated in REACH and questioned concerning their health and environmental properties.

Nevertheless, there are several families of plasticisers other than phthalates which rise less environmental and health concerns. Among them there are:

- Adipates
- Sebacates
- Azelates
- Citrates
- Trimellitates
- Organic phosphates
- Polymeric plasticizers
- Epoxidized vegetabilic oils

The selection of a plasticiser depends on several criteria as listed below:

- Compatibility with the current polymer
- Appropriate processing behaviour
- Required electrical and mechanical properties in the end product.
- Plasticiser impact on rheological properties
- Health and environmental impact
- Price

Information of the single groups are given in the following tables.

Table 5 Information on adipates

Adipates are usually used in cables	
Physical properties of adipates: • Flexibility at low temperatures • Volatile • Low viscosity	
Some examples of adipates on the market:	
Name	**CAS No.**
• Di(2-ethylhexyl) adipate (DEHA), Dioctyl adipate (DOA)	103-23-1
• Dibutyl adipate (DBA)	105-99-7
• Diisobutyl adipate (DIBA)	141-04-8

• Diisooctyl adipate (DIOA)	1330-86-5
• Diisononyl adipate (DINA)	33703-08-1
• Diisodecyl adipate (DIDA)	27178-16-1
Toxicity of adipates	
• The health impact of DEHA:s has been questioned	
• Not classified as carcinogens	
• Not toxic for humans	
• Low potential for skin irritation and allergy	
• Degradable by organisms and therefore not bioaccumulative	

Table 6 Information on sebacates and azelates

Sebacates and azelates. Relevant uses are for applications used in extremely low temperatures for instance frost resistant cables and mouldings for e.g arctic conditions	
Physical properties	
• Excellent flexibility at very low temperatures	
• More expensive than adipates	
Toxicity	
• Dibuthyl sebacate has potential for contact allergy at frequent exposure.	
• Not carcinogenic nor toxic.	
• Di(2-etylhexyl)sebacate is not skin irritation, cause allergy or carcinogenic.	
Some examples of sebacates and azelates on the market	
Name	**CAS No.**
• Dibutyl sebacate, (DBS)	109-43-3
• Dioctyl sebacate (DOS), Di-2-ethylhexyl sebacate	122-62-3
• Diisodecyl sebacate (DIDS)	28473-19-0
• Dioctyl azelate (DOZ),; Di-2-ethylhexyl azelate	103-24-2
• Dimethyl azelate	1732-10-1

Table 7 Information on citrates

Citrates family of plasticisers are not relevant for the applications studied according to current knowledge.
Physical properties
• Non toxic
• Relatively volatile
• Sensitive towards oils
Toxicity
• ATBC is classified as safe in toys

• No or low potential for skin irritation or allergy • No or low toxicity • Not carcinogenic
Some examples of citrates on the market

Name	CAS No.
• Acetyl triethyl citrate (ATEC)	77-89-4
• Acetyl tri-n-butyl citrate (ATBC)	77-90-7
• N-butyryl tri-n-hexyl citrate (BTHC)	82469-79-2
• Triethyl citrate (TEC)	77-93-0
• Tributyl citrate (TBC)	77-94-1

Table 8 Information on trimellitates

Relevant uses are for cables that operate under high temperatures
Physical properties • Low volatility • Low migration • Good electric properties • Stability at high temperatures
Toxicity • Toxicity for TEHTM in medical applications – Almost no evidence of negative effects • TEHTM is skin and eye irritating but does not cause allergy on testing animals • Irritating through inhalation or orally on rats. • There is no data on carcinogenicity • Bioaccumulative but data concerning biological impact are missing.
Some examples of Trimellitates on the market

Name	CAS No.
• Tri(2-ethylhexyl) trimellitate (TEHTM)	\3319-31-1
• Trioctyl trimellitate (TOTM)	\3319-31-1
• Tri-n-hexyl trimelliate	\1528-49-0
• Trimethyl Trimelliate	\2459-10-1
• n-Octyl, n-Decyl Trimellitate	67989-23-5
• Tri(heptyl,nonyl) Trimellitate	68515-60-6

Table 9 Information on organic phosphates

Relevant uses are for migration and flame resistant cables	
Physical properties	
• Very low volatility	
• Resistant towards migration	
• Decreased plasticising effects	
• High viscosity	
• Sometimes mixed with other plasticisers e.g. phthalates	
Toxicity	
• TEHP is not a skin irritant on humans	
• Low toxicity on testing animals	
• Probably not carcinogenic	
• Biodegradable	
• Diphenylcrecylphosphate is toxic for water organisms and bioaccumulative. Monitored concentrations are below those for toxic impact (NOAEL)	
Some examples of organic phosphates on the market	
Name	**CAS No.**
• 2-Ethylhexyl diphenyl phosphate	1241-94-7
• Tricresyl phosphate	1330-78-5
• Triethyl phosphate	78-40-0
• Triphenyl phosphate	115-86-6
• Tri(2-ethylhexyl) phosphate (TEHP)	78-42-2

Table 10 Information on polymeric plasticiser

Relevant uses are for migration resistant cables
Physical properties
• Very low volatility
• Resistant towards migration
• Decreased plasticising effects
• High viscosity
• Sometimes mixed with other plasticisers e.g phthalates
Some examples of Polymeric plasticiser on the market:
• Acid (sebacine-, azelaine- eller adipinic acids + polyol polyester
• Examples of trade names: Palamoll, Paraplex, Admex

Table 11 Information on epoxidized vegetabilic oils

Relevant uses in cables together with other plasticisers e.g DEHP	
Physical properties • Secondary plasticiser meaning the vegetabilic oil does not improve the polymer flexibility by its own but only together with a primary plasticiser, which are those substances except polymeric plasticisers, described above • Low volatility and migration • High viskosity • Low plastizising effect	
Some examples of Polymeric plasticiser on the market	
Name	**CAS No.**
• Epoxidized soybean oil (ESO/ESBO)	8013-07-08
• Epoxidized linseed oil (ELO)	8016-11-03

6.9 Feasibility aspects for chemicals with intended uses (functionalities) versus impurities in imaging equipment

Matter in the forms we know them in daily life are in different shapes and composition such as

- Metals and alloys
- Polymers
- Preparations and substances

The term polymer is an extensive term of materials that are made of large molecules built up by small and simple chemical units in several repetitive ways. Polymers are formed by nature or by man. The latter kinds of polymers are either synthetic of regenerated from natural occurring polymers such as cellulose. The basic properties of these polymers either there have their origin from nature or man there is sometimes a need to adopt their native behavior into preferred technical and quality properties i.e. stiff polymers into a softer polymer, an easy burning polymer into a fire retardant polymer etc.

In order to achieve these technical modifications there is a need to incorporate functionalities, either as chemicals or groups of chemicals that interact in such a way that they achieve these preferred functionalities under certain critical circumstances that could inflict the polymer during its uses. Beside the preferred functionalities the chemicals in cooperated in the polymer may cause non preferred properties to the polymer that may inflict its suitability to be used on the market in a feasible way. As many properties of these chemicals need to be defined and understood on their functional characteristics as much as possible before and during use.

In order to understand and predict the physical behaviour of chemicals we need to define different categories depending on the purpose for their presence in a certain material. On the basis of this philosophy, three main categories of chemicals may be distinguished namely:

- Chemicals with certain functionality/ies in the final product, mentioned as functional chemicals
- Chemicals with no functionality/ies in the final product, mentioned as impurities.
- Chemicals that occur through unintended production by man or nature, mentioned as impurities.

Functional chemicals represent a very large group of chemicals of inorganic and organic compounds. They are either additive or reactive. They should be clearly separated by definition from chemicals that are addressed as impurities that have very low or no logical explanatory history of their presence in the polymer, since they don't contribute to the preferred technical properties of the polymer. This does not mean that they are less relevant concerning their possible impact on health and/or environment, but they are beyond any explanatory and predictable control at later stages of the polymer life cycle.

Reactive functional chemicals are added during the polymerisation process and become an integral part of the polymer and form a co-polymer. The result is a modified polymer with required functional properties and different molecule structure compared to the original polymer molecule.

Additive functional chemicals are incorporated into the polymer prior to, during, or more frequently after polymerisation. Additive functional chemicals are monomer molecules that are not chemically bounded to the polymer. They may therefore, in contrast to reactive functional chemicals, be released from the polymer and thereby also discharged to the environment.

Some additives can appreciably impair the properties of polymers. The basic problem is the trade-off between the decrease of performance of the polymer caused by the functional chemical and the preferred requirements. In addition to fulfilling the appropriate technical and quality requirements set by the market and society, a feasible functional chemical shall, at most, fulfil all of the qualities mentioned below.

Preferred functional properties:

- Fillers
- Plasticisers and softeners
- Lubricants and flow promoters
- Anti-ageing additives
- Flame-retardants
- Colourants
- Blowing agents
- Cross-linking agents
- Ultra-violet degradable additives
- etc

Mechanical properties:

- Not significantly alter the mechanical properties of the polymer
- Be easy to incorporate into the host polymer
- Be compatible with the host polymer
- Should be stable under processing and service of life conditions

Physical properties:

- Be colourless or at least non-discolouring properties
- Have good light stability
- Be resistant towards ageing and hydrolysis
- Not cause corrosion
- Should not bleed or bloom
- Should be stable under processing and service of life conditions
- Not negatively impact the recycling
- Not considerably negatively impact end of life schemes

Health and environmental properties:

- Not have harmful health effects
- Not have harmful environmental properties

Commercial viability:

- Be commercially available and cost efficient

Additional requirements for flame retardants:

- Start its thermal behaviour prior to the thermal decomposition of plastics
- Not or hardly emit toxic gases
- Should not adversely affect electrical properties in printed board laminates and plastic encapsulated devices
- Must fulfil safety requirements in terms of current tracking and arcing (for connectors, plugs etc.)

These requirements are obviously almost impossible to meet simultaneously for any single application. However, many formulations have been developed that meet these requirements as close as possible.

6.10 Information for TBBPA

6.10.1 TBBPA references related to dioxin and furan formations

Based on the list of references in Table 12 it can be concluded that dioxins and furans (PDD/F) are formed during incineration and thermal treatment of Br-FR containing materials, and PBDE-containing materials in particular.

This goes back to published studies from Buser, 1986 and is later also concluded by both Ebert & Bahadir, 2003 and Weber & Kuch, 2003 with many references. Later studies have shown that PBDD/F are formed through photolytic degradation of PBDE (decaBDE into PBDF; Söderström et al. 2004, Hagberg et al. 2006, Kajiwara et al 2008), and that PBDF are present in the technical mixtures (commercial) of PBDE-mixarna (Hanari et al 2006) and in products already treated with these commercial PBDE-products (Tamade et al. 2002). Luijk et al. 1992 showed that PBDF are formed during mild thermal treatments of plastics.

Since then several studies have also concluded the formation of PBDD/F during a wide range of incineration processes (Söderström & Marklund 2002, 2004, Sakai et al 2001, Wichmann et al 2002).

Table 12 References regarding TBBPA and dioxin/furans formation

Buser HR. (1986) Polybrominated Dibenzofurans and Dibenzo-p-dioxins: Thermal Reaction Products of Polybrominated Diphenyl Ether Flame Retardants. *Environ. Sci. Technol.* 20, 404-408.
Ebert J, Bahadir M. (2003). Formation of PBDD/F from flame-retarded plastic materials under thermalstress. *Environ. Int.* 29, 711-716.
Hagberg, J., H. Olsman, *et al.* (2006). "Chemical and toxicological characterisation of PBDFs
from photolytic decomposition of decaBDE in toluene." Environment International 32(7): 851-857.
Hanari N, Kannan K, Miyake Y, Okazawa T, Kodavanti PRS, Aldous KM,Yamashita N. (2006) Occurrence of polybrominated biphenyls, polybrominated dibenzo-p-dioxins and polybrominated dibenzofurans as impurities in commercial polybrominated diphenyl ether mixtures. *Environ. Sci. Technol.*40, 4400-4405.
Kajiwara N, Noma Y, Takigami H. (2008) Photolysis studies of technical decabromodiphenyl ether (decaBDE) and ethane (deBDethane) in plastics under natural sunlight. *Environ. Sci.*

Technol. 42, 4404-4409.
Sakai, S.-i., J. Watanabe, *et al.* (2001). "Combustion of brominated flame retardants and behavior of its byproducts." Chemosphere 42(5-7): 519-531.
Söderstrom G, Marklund S. (2002) PBCDD and PBCDF from incineration of waste-containing brominated flame retardants. *Environ. Sci. Technol.* 36: 1959-1964.
Söderstrom G, Marklund S. (2004) Formation of PBCDD and PBCDF during flue gas cooling. *Environ.Sci. Technol.* 38: 825-830.
Tamade Y, Shibukawa S, Osaki H, Kashimoto S, Yagi Y, Sakai S et al. (2002) A study of brominated compounds release from appliance-recycling facility. Organohal. Comp. 56:189-192.
Weber R, Kuch B. (2003) Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated-chlorinated dibenzodioxins and dibenzofurans. *Environ. Int.* 29, 699-710.
Wichmann, H. et al. "Thermal formation of PBDD /F from tetrabromobisphenol A–a comparison of polymer linked TBBPA with its additive incorporation in thermoplastics." Chemosphere, vol. 47 (2002): 349–355

6.10.2 TBBPA properties related to direct health and environmental impacts

The main properties of TBBPA[59] are presented below.

<u>Endocrine disruption</u>

There are indications of potential effects on the endocrine system in some *in vitro* tests with aquatic organisms (EU RAR TBBPA 2007). However, these effects could not be confirmed by *in vivo* studies. For mammalian systems, the human health assessment concludes that the weight of evidence from in vitro screening in assays indicates that TBBPA has no significant estrogenic potential in mammalian systems. It should, however, be noted that the effects of TBBP-A on the endocrine system are subject to current research (e.g. in the EU FIRE project[60]). The FIRE project (Flame retardants Integrated Risk assessment for Endocrine effects) supported by the European Commission investigates the possible emerging health risk for humans and wildlife of brominated flame retardants (BFRs) including TBBP-A by endocrine related mechanisms. Final results of this study are not yet available.

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[59] Rita Gross et al, Final Report "Study on Hazardous Substances in Electrical and Electronic Equipment, Not Regulated by the RoHS Directive" for DG ENV, Oeko Institut 2008, available online at: http://ec.europa.eu/environment/waste/weee/pdf/hazardous_substances_report.pdf.

[60] FIRE (Flame retardants Integrated Risk assessment for Endocrine effects): Risk Assessment of Brominated Flame Retardants as Suspected Endocrine Disrupters for Human and Wildlife Health, as of October 2011.

PBT and vPvB evaluation

TBBP-A is considered to be persistent (P) or potentially very persistent (vP) based on its ultimate mineralisation. The available information on bioaccumulation shows that TBBPA does not meet the B or vB criterion. The highest measured bioconcentration factor (BCF) value for fish is 1 234 l/kg. This value is below the cut-off value of 2 000. However, it should be noted that available monitoring data presented in the EU RAR TBBP-A (2007) suggest that the substance is present at low levels in the tissues of a wide variety of marine organisms including some top predators, predatory birds from remote areas (e.g. northern and arctic regions of Norway) and human breast milk from remote areas (e.g. the Faroe Islands; see Table 13). The T (toxicity) criterion is not met by this substance. TBBPA does not fulfil the criteria for substances of very high concern (SVHC) as defined by REACH.

6.11 Investigation for brominated aromatic additives used in plastics

6.11.1 Background information of brominated aromatic flame retardants

In this section, an overview of the field of the most commonly found brominated aromatic flame retardants is presented. Information with regard the different types of FRs and in which plastic parts they are used is given. The relevant reference list for this section is given in Table 14:

Flame retardants are commercially used in PC, PC-blends, ABS, SAN and PET. The average loads are between 10 – 20% w/w and depend on the specific requirements and properties needed for the end product as presented in more detail in Table 13.

A selection of brominated flame retardants commercially used in PC, PC blends, ABS, SAN and PET is presented in Table 13.

Table 13 A selection of brominated flame retardants commercially used in PC, PC blends, ABS, SAN and PET[61]

Additive used for the flame retardant properties			Material				
Chemical name		CAS RN	Poly carbonate (PC)	Poly carbonate blends (PC/ABS)	Acrylo nitrile butadiene styrene terpolymer	Styrene acrylo nitrile copolymer (SAN)	Poly ester (PET)
BROMINATED FLAME RETARDANTS (BFr)	Brominated polystyrene/ATO[62]	88497-56-7					X
	DecaBDE/ATO	1163-19-5	X	X		X	
	Decabromodiphenyl Ethane/ATO	84852-53-9	X	X		X	
	Ethylene bistetrabromo phthalimide	32588-76-4	X	X			X
	Pentabromobenzyl acrylate	85-22-3					X
	Poly(pentabromobenzyl acrylate) / *as polymer* Pentabromobenzyl acrylate / as reactive monomer	59447-55-1	As polymer	X	As monomer		As monomer
	Pentabromotoluene	87-83-2			X		X
	TBBP-A	79-94-7	X	X			
	TBBPA carbonate oligomer				X		
	Tris(tribromoneopentyl) phosphate	19186-97-1				X	
	1,2-Bis(2,4,6-tribromophenoxy)ethane	37853-59-1			X		

[61] Norwegian EPA (KLIF), " EMERGING "NEW" BROMINATED FLAME RETARDANTS IN FLAME RETARDED PRODUCTS AND THE ENVIRONMENT" (2009)

[62] ATO: Antimony trioxide, CAS Nr: 1309-64-4 , a common synergist together with brominated flame retardants

Polybrominated diphenylethers (PBDEs) are a group of additive flame retardants. The term PBDE includes commercial pentabromodiphenylether (C-PentaBDE), commercial octabromodiphenylether (C-OctaBDE) and commercial decabromodiphenylether (C-DecaBDE), which are commercial mixtures of homologues of brominated diphenylethers with various substitution levels of bromine substituted to the aromatic rings.

Since C-PentaBDE and C-OctaBDE, due to their hazardous properties, have been phased out in several regions and countries worldwide, C-DecaBDE is the PBDE still produced and used in large quantities worldwide.

DecaBDE is applied in the range between 10%-30% of the polymer weight to various polymers such as styrenics and polyolefins, but may also be applied in textile back coatings. The vast majority of the decaBDE currently produced is used in the outer casing of electric equipment.

In order to reduce the overall amount of brominated-FR use in a polymer, the synergist antimony[63] is often added in the form of antimony trioxide. DecaBDE has an optimum applied ratio with antimony trioxide of *1 part antimony: 3 parts bromine*, which has shown to be the most effective ratio concerning flame retardant synergetic effects in a wide range of polymers in order to achieve optimum fire retardant properties.

TBBPA is an aromatic brominated organic compound and, as previously described, is primarily used as a reactive intermediate in the manufacture of flame retarded epoxy and polycarbonate resins. Therefore, it is an integral part of the polymer.

Further, TBBPA may also be used as an additive flame retardant physically mixed into the polymer, for example in the manufacture of acrylonitrile-butadiene-styrene resins (ABS) and phenolic resins. When TBBPA is used as an additive flame retardant it is usually with antimony trioxide which is not the case when it is used as a reactive flame retardant.

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[63] The term synergistic effect is used in the connection with the development of flame retardants. This term means that the desired effect of two or more components working together is greater than the effect of each component separately. Perhaps one of the most important effects historically in flame retardant chemistry is the one between halogen and antimony, where antimony reacts in the form of antimony trioxide with the formation of radicals, finally forming antimony tribromide and antimony oxibromide and their chlorinated equivalents. These flame retardants react in gaseous phase and usually contain halogens of the bromine and chlorine type.

TBBPA is also used for the manufacture of derivatives to TBBPA-dimethylether, TBBPA-dibromopropylether, TBBPA-bis(allylether), TBBPA-bis (2-hydroxyethyl ether), TBBPA-brominated epoxy oligomers and TBBPA-carbonate oligomers.

Besides the PBDEs and TBBPA and its oligomers, there are several other aromatic brominated flame retardants that may be applied in imaging equipment.

Table 14 Reference list 1 for brominated flame retardants

Alaee, M; Arias, P; Sjödin, A; Bergman, Å: An overview of commercially used brominated flame retardants, their applications, their pattern use in different countries/regions and possible modes of release", Environment International 29 pp 683 – 689. (2003)
Bromine Science Environmental Forum - Science & Knowledge dedicated to Bromine and BFRs, www.bsef.org
Braun B, Schartel B , Mario A. Fichera and Jäger C, Flame retardancy mechanisms of aluminium phosphinate in combination with melamine polyphosphate and zinc borate in glass-fibre reinforced polyamide 6,6", Polymer Degradation and Stability, Volume 92, Issue 8, Pages 1528-1545 (2007). http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TXS-4NSMMS6-3&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1044151944&_rerunOrigin=google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=062ad975d5c94044216ecd7e12dd10cd - aff2
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Cusack, P.A, "Tin-based fire retardants in halogen-free polymer formulations" (2005)
Danish Environmental Protection Agency (Danish EPA), "Brominated Flame retardants – substance flow analysis and assessment of alternatives", (1999).
Environmental Health Criteria (ECH) 162, "Brominated diphenylethers" (1994).
Kashiwagi, T; Du, F; Douglas, J; Winey, K; Harris, R; Shields, J: "Nanoparticle networks reduce the flammability of polymer nanocomposites", Nature Materials, vol 4, pp 928 -933, (2005).
KemI (Swedish Chemicals Agency), "Hexabromocyclododecane (HBCD) and tetrabromobisphenol (TBBPA)", Report no 3/06 (2006).
KemI (Swedish Chemicals Agency),"DekaBDE – rapport från ett regeringsuppdrag", Report 1/09 (2009)
Lein Tange* & Dieter Drohmann "WASTE MANAGEMENT OF PLASTICS CONTAINING BROMINATED FLAME RETARDANTS" DSBG Eurobrom, Great Lakes Chemical, 2001
S. Lundstedt, "Emissions, transformation and formation of brominated substances during fires", University of Umeå , 2009 (Written in Swedish)
Norwegian EPA (KLIF), " EMERGING "NEW" BROMINATED FLAME RETARDANTS IN FLAME RETARDED PRODUCTS AND THE ENVIRONMENT" (2009)
Pinfa, "Non-halogenated phosphorous, inorganic and nitrogen flame retardants", CEFIC, (2009)
PlasticsEurope (2009), European Plastics Industry (EU 27), PlasticsEurope Market Research Group, Statistical Monitoring December (2009)
Posner, S: "Survey and technical assessment of alternatives to Decabromodiphenylether (decaBDE) in textile applications", PM 5/04 KemI (2004).
Posner, S; Börås, L: "Survey and technical assessment of alternatives to Decabromodiphenylether (decaBDE) in plastics", Report 1/05 KemI (2005).
Posner S, "Survey and technical assessment of alternatives to TBBPA and HBCD" report3/06 KemI (2006)

Posner, S. "Guidance on alternative flame retardants to the use of commercial pentabromodiphenylether (c-PentaBDE)", UNEP-POPS-POPRC.4-INF-13.English.pdf (2009)
Renner, R: "PBDE – Polybrominated diphenylethers – What fate for Brominated Fire retardants?", Environmental Science and technology – American Chemical Society (2000).
Norwegian Pollution control Authority (SFT), Mikael H, Eldbjørg S. Heimstad, Herzke D ,Tork, Sandanger J, Posner S and Wania F, "Current State of Knowledge and Monitoring requirementsEmerging "new" Brominated flame retardants in flame retarded products and the environment", (2009)
R. Weber and B Kuch "Relevance of BFRs ang thermal conditions on the formation pathways of brominated and brominated-chlorinated dibenzdiozins and dibenzofurans", Environ Int. 2003 Sep;29(6):699-710.
SRI consulting, http://www.sriconsulting.com/ (2008).
Swaraj, P: "State of the art study for the flame retardancy of polymeric. materials with some experimental results", PP Polymer AB (2001).
T. Retegan and J. Felix M. Schyllander, " Recycling of WEEE Plastics Containing Brominated Flame Retardants - a Swedish perspective Report to the Swedish Environmental Protection Agency(April 2010)
Troitzsch, J: Commercially available halogen free alternatives to halogen-containing flame retardant systems in polymers", (2008).
UNEP, "Summary of the proposal for the listing of hexabromocyclododecane (HBCD) in Annex A to the Convention", (2008) http://chm.pops.int/Portals/0/Repository/poprc4/UNEP-POPS-POPRC.4-11.English.PDF

6.11.2 Life cycle consideration of brominated aromatic flame retardants

Environmental concerns about the use of Brominated flame retardants are raised due to their role in the formation of Br-dioxins (PBDD), Br-furans (PBDF) as well as Br/Cl-dioxins (PXDD) and Br/Cl-furans (PXDF) when chlorine is present.

In general the degree of Bromine containing dioxins and furans formation depends on the precursor quality and on the type of treatment. In Table 15 the potential of dioxin formation in relation to the thermal treatment undertaken is given. All brominated aromatic compounds can act as PBDD/PBDF precursors in thermal processes of:

a) pyrolysis /gasification as in this case 350 – 800 °C is often reached with low oxygen content (category 2 of Table 15) and;

b) in thermal processes with insufficient combustion conditions i.e. incinerators operating in non-BAT conditions, secondary metal plants, uncontrolled burning (3 of Table 15).

The relevance of incinerators operating in non-BAT conditions is higher as a large share of e-waste (including exported European electronics and e-waste) or plastic from e-waste is finally treated in developing countries and countries in transition economies under such conditions.

Table 15: Categories of thermal treatment, related actual processes, prevailing formation pathways ways and potential of PBDD/PBDF formation (Weber and Kuch 2003)

Category	Processes	Conditions	Prevailing formation pathways	PXDD/PXDF formation potential
1) Thermal stress	Production, recycling (include shredding, molding and extrusion)	100 – 300 °C, mechanical stress	Selected precursors (e.g. PBDEs)	Low -> moderate
2) Pyrolysis/gasification	Pyrolysis/gasification facilities (pyrolysis of plastics, shredder fractions or sludges). Accidential fires; uncontrolled burning	350 – 800 °C, low oxygen content	Precursors + formation of aromatic compounds and halogenation.	High
3) Insufficient combustion conditions	Accidental fires, uncontrolled burning, non-BAT incinerators. Secondary metal plants	Uncontrolled parameters: temperature, residence time, oxygen content, turbulence.	Precursors	High
4) Controlled combustion conditions	BAT incinerators, cement plants	Optimised combustion control	Formation of aromatic compounds and halogenation	Low

With regard to brominated dioxins and furans, the precursor pathway for their formation can be identified more easily than in the case of Cl-dioxins and Cl-furans (PCDD/PCDF) in which the precursor pathway for their formation cannot be identified precisely. Bromine is primarily present in specific plastics.

Bromine is found in plastics in the form of BFRs. Brominated aromatic compounds can act as precursors for PBDD/PBDF formation (e.g. brominated diphenylethers (PBDEs) or brominated phenols (PBP)). Hence, the precursor pathway is of higher relevance for the formation of polybrominated dibenzodioxins (PBDDs) and polybrominated dibenzofurans (PBDFs) during thermal processes compared to their chlorinated analogues.

PBDD/PBDF and brominated-chlorinated PXDD/PXDF have similar toxicity as PCDD/PCDF and sometimes even exceed the toxicity of their chlorinated counterparts (see Annex 6.11.6). PBDD/PBDF and PXDD/PXDF are relevant contributors to dioxin-like exposure to humans.

The total amounts of brominated dioxins/furans generated from the polybrominated diphenyl ethers alone are estimated in the tonnes scale and are comparable in magnitude to the total global release of chlorinated dioxins and furans from all thermal sources combined (Zennegg et al. 2009).

During the entire life cycle of BFR-containing materials, PBDD/PBDF, and in the presence of a chlorine source also brominated-chlorinated PXDD/PXDF, can be formed and released into the environment (Ebert and Bahadir 2003, Kajiwara et al.2008; Kajiwara & Takigami 2010; Weber and Kuch 2003; WHO 1998).

Hence, a key concern regarding brominated flame retardants (this is applicable also for halogenated FRs in general) is at their end-of-life management. The three main options for materials treated with aromatic brominated flame retardants and other halogenated flame retardants are:
(1) recycling,
(2) incineration/thermal,
(3) land filling.

Management of end-of-life waste flows can vary widely based on the type of waste management schemes used in various countries and the different materials involved (e.g. flame-retarded plastic in e-waste). The relevant environmental concerns raised for each option of waste management will further be analysed in more detail.

As there are numerous studies in which the environmental considerations along the product life cycle of products containing brominated flame retardants, which are related to the formation of Br-dioxin (PBDD) and Br-Furans (PBDF), are highlighted. A list of references used is given in section 6.11.9 of Annex 6.11.

6.11.3 Recycling of Brominated Flame Retarded Materials

The advantage of mechanical recycling as a method for end-of-life treatment of flame retarded materials is that it contributes to the overall reduction of the energy-intensive production of new materials.

Brominated aromatic flame retardants are precursors of brominated dioxins and brominated dibenzofurans. Some brominated aromatic BFRs (in particular PBDE) can form brominated dibenzofurans, even during necessary recycling operations like extrusion and molding of new plastic products requiring elevated temperatures (Meyer et al 1993, Mc Alister 1990, Weber and Kuch 2003).

Further, significant material flows containing halogenated flame retardants and other toxic materials are often exported to developing/transition countries and recycled there with cheap labour and primitive methods[64] (see also Annex 6.12). As documented for global e-waste flow or shipment, these recycling practices have resulted in large-scale environmental and human contamination (Basel Action Network 2002, Greenpeace 2008, Wong et al 2007, Bi et al 2007, Leung et al 2007, Luo et al 2008).

Recycled PBDE-containing plastics are frequently contaminated with PBDDs/PBDFs, and it has been reported that it can exceed legislative limits (Mayer et al 1993, Schlummer et al 2007). Moreover, workers in industrial countries can be exposed to high levels of brominated flame retardants and other toxic chemicals during the recycling of e-waste (including the plastic fraction) or during production of i.e. polyurethane foam (Sjödin et al 2001, Stapelton et al. 2008). In industry reports it has been also concluded that mechanical recycling of such plastic waste is not recommended (Mayer et al 1993, Mark 2006).

However, it is common practise that mixed plastic fractions from electronic waste are normally not reused in electronics but are mostly “downcycled” into less demanding applications. Recent studies showing that brominated flame retardants are present in plastic household goods (Chen et al 2010), video tape casings (Hirai and Sakai 2007) and plastic children's toys. Chen et al. 2009 have revealed that such downcycling takes place in an uncontrolled manner for BFR-containing plastics. These practices dilute BFRs and

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[64] Siddharth Prakash, Andreas Manhart, Yaw Amoyaw-Osei, Obed Opoku Agyekum "Socio-economic assessment and feasibility study on sustainable e-waste management in Ghana for Inspectorate of the Ministry of Housing, Spatial Planning and the Environment of the Netherlands (VROM-Inspectorate) and the Dutch Association for the Disposal of Metal, and Electrical Products (NVMP), Oeko Institute 2010, http://www.oeko.de/oekodoc/1057/2010-105-en.pdf

chlorinated flame retardants in plastic streams, leading to unnecessary human exposure to plastic products from recycled materials. This shifting of environmental burdens from one product life cycle to another highlights the importance of focusing on environmental strategies in which prevention of environmental impacts shall be the first priority.

6.11.4 Incineration/thermal treatment of materials containing halogenated flame retardants

It should be highlighted that BFRs can be destroyed with high efficiency if BFR/HFR-containing wastes are destroyed in incinerators constructed according to best available technology (BAT) and operated according to best environmental practice (BEP) (Sakai et al 2001, Vehlow et al 2000, Weber and Kuch 2003). However, for BAT incineration, costs per tonne of incinerated material are high (in the order of $100/t) and such facilities are too costly for treating municipal waste in developing/transition countries (Brunner and Fellner 2007).

Nonetheless, even in BAT grate incinerators (the technology applied in most municipal waste incinerators), elevated PBDD/PBDF levels were found in the bottom ashes (Wang et al 2010b), most probably due to grate shifting (particle matter falling through the grate not subjected to a compete burnout).

A large proportion of brominated flame retarded materials are combusted. Depending on the quality of combustion, high levels of brominated dioxins and furans can be formed and released as a result of the dioxin precursor properties of aromatic brominated flame retardants (Weber and Kuch 2003). In particular, open burning of e-waste is estimated to globally generate PBDDs/PBDFs and PXDDs/PXDFs on a scale of tonnes (Zennegg et al 2009) and for many geographical areas can be considered as common practice. Areas in which such open e-waste burning has been practised for years have been transformed into PCDD/PCDF, PBDD/PBDF and PXDD/PXDF contamination sites (Li et al 2007, Yu et al 2008, Zennegg et al 2009). With regard to chlorinated PCDD/PCDF its source for the release is the presence of PVC as reported by Zennegg et al 2009.

PBDD/PBDFs are also emitted from open waste burning in industrial countries (Gullett et al 2010), other open burning practices, and other sources (Ebert and Bahadir 2003). Large amounts of brominated flame retardants in e-waste (together with car interiors) are treated in the metal industry for recovery of precious metals from e-waste (or iron and aluminium from cars and other goods). These operations can be regarded as an incomplete combustion process resulting in the emission of PBDD/PBDFs and halogenated flame retardants (Wang et al 2010a, Odabasi et al 2009).

6.11.5 Deposition and release of halogenated flame retardants from landfills

A large portion of HFR-treated products end up in landfills. This is particularly true for end-of-life treatment in developing and transition countries having no thermal waste treatment options other than open burning or other limited incineration methods not meeting BAT requirements. Even in industrialized countries, a large share of flame retarded wastes is landfilled, as was recently documented in California (Petreas and Oros 2009). It is worth highlighting that in many countries there are very few or even no waste incineration capacities at all (i.e. Australia which is an industrialised country).

There is growing evidence and concern that brominated flame retardants including POPs/PBDEs are leaching from landfills and contaminating the environment (Danon-Schaffer 2010, Odusanya et al 2009, Oliaei et al 2002, Osako et al 2004, Weber et al 2010). Significant PBDE emissions in leachates are detected from landfills in industrial countries (Danon-Schaffer 2010, Oliaei et al 2002, Osako et al 2004). Substantial concentrations of PBDEs were present in the soil adjacent to all landfills and dumpsites in various regions of Canada (Danon-Schaffer, 2010), revealing significant POP/PBDE releases from landfills in an industrial country.

Recently, PBDE-contaminated groundwater from South African landfills has been reported (Odusanya et al 2009), indicating that new POPs/ PBDEs are present in significant amounts in the end-of-life stage in developing/transition countries and are adding to the environmental contamination generated by primitive e-waste recycling.

However, with engineered landfills with bottom liners, leachates that escape to the environment can be collected and treated to reduce the flow of contaminants to ground and surface water for some time (Osako et al 2004). Nevertheless, such treatments are expensive, and the resulting solids from adsorption of pollutants need further treatment or deposition. Because of their persistence, POPs/PBDEs will remain in landfills for many decades – and probably centuries. Over these extended time frames, landfill engineering systems, including basal and capping liners, gas and leachate collection systems, will inevitably degrade and lose their ability to contain the contaminants (Buss, Butler et al. 1995; Allen 2001, Danon-Schaffer, 2010). Therefore, land filling does not appear to be a sustainable solution for long-term containment of brominated FR-treated materials and other persistent organic pollutant-containing waste.

6.11.6 Toxicity of brominated dioxins and brominated furans, and mixed halogenated dioxins and furans

Brominated dioxins and furans have been shown to have toxicities similar to, and in some cases greater than, their chlorinated counterparts in human cell lines and mammalian species (World Health Organisation1998; Birnbaum et al. 2003; Weber & Greim 1997; Behnisch et al. 2003; Samara et al. 2010; Olsman et al. 2007; Matsuda et al. 2010; D'Silva et al. 2004). Thymic atrophy, wasting of body mass, lethality, teraterogenesis, reproductive effects, chloracne, immunotoxicity, enzyme induction, decreases in T_4 and vitamin A, and increased hepatic porphyrins have been observed in animal studies of both brominated and chlorinated dioxins and furans (WHO, 1998, Birnbaum et al 2003, Weber and Greim 1997). *In vitro* responses of brominated PBDD/DF are similar to chlorinated PCDD/PCDF, including enzyme induction, anti-oestrogen activity in human breast cancer cells, and transformation of mouse macrophages into tumour cells and standard bio assays for dioxin-like toxicity testing (World Health Organisation 1998; Behnisch et al. 2003; Samara et al. 2010; Samara et al. 2009; Olsman et al. 2007; Matsuda et al. 2010).

In particular it should be emphasised that 2,3,7,8-Tetrabromodibenzofuran (2,3,7,8-TBDF) has a dioxin-like toxicity close to 2,3,7,8-TCDD (Matsuda et al. 2010; Behnisch et al. 2003; Samara et al. 2009; Samara et al. 2010) and is therefore far more toxic than the 2,3,7,8-TCDF. This is of particular concern because 2,3,7,8-TBDF is one of the most prevalent PBDD/PBDF congeners in human tissue (Ericson Jogsten et al. 2010) and human milk samples (Kotz et al. 2005) but can also be rather high in flame retarded plastics from WEEE (Riess et al. 2000).

Recent studies indicate that some brominated-chlorinated (PXDD/DF) dioxins/furans also have similar, and for some mixed congeners possibly greater, toxicity compared to their chlorinated homologues (Behnisch et al.2003; Mennear and Lee 1994; Birnbaum et al. 2003; Olsman et al. 2007; Matsuda et al. 2010). It is particularly notable that 2,3-Dibromo-7,8-dichlorodibenzopdioxin and 2,3,7,8-T4BDD are shown to elicit up to 2.5 times the toxic response of 2,3,7,8-T4CDD, often thought to be the most toxic anthropogenic chemical. With regard to the contemporary relevance of PBDD, PBDF and brominated-chlorinated PXDD/PXDF more information is given below.

In conclusion, PBDD/PBDF and brominated-chlorinated PXDD/PXDF are of high concern similar to PCDD/PCDF and the prevention of their formation is of particular importance.

6.11.7 Contemporary relevance of PBDD, PBDF and brominated-chlorinated PXDD/PXDF

Today brominated dioxins and furans are relevant dioxin contributors in daily life as can be derived from their high contribution (about 30%) of the dioxin-like toxicity in food in the UK[65] (Rose et al 2010) It is notable that the EU country with the most stringent flame retardant standards (UK) report on this consistently high PBDD/PBDF and PXDD/PXDF levels in food. A direct link between these PBDD/PBDF levels and the BFR use have not been established yet.

Furthermore PBDD/PBDF were found as the major dioxin-like compounds in the first comprehensive assessment of dioxin-like compounds in house dust. The dioxin-like PBDF levels considerable exceeded the dioxin-like contribution of polychlorinated dioxins, furans and dioxin-like PCBs[66] (Suzuki et al 2010). While for PCDD/PCDF food exposure is for the average population the most relevant exposure pathway for the PBDD/PBDF the indoor contamination of house dust from flame retarded material can have a significant contribution or is probably the most relevant exposure pathway.

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[65] Rose, M.D. Fernandes, A.R. (2010). Are BFRs responsible for brominated dioxins and furans (PBDD/Fs) in food? BFR2010. Kyoto

[66] Suzuki, G.,Someya, M. Takahashi, S, Tanabe, S. Sakai, S., Takigami, H. (2010). Dioxin-like Activity in Japanese Indoor Dusts Evaluated by Means of in Vitro Bioassay and Instrumental Analysis: Brominated Dibenzofurans Are an Important Contributor Environ. Sci. Technol.44 (21), 8330–8336

PBDD/PBDF have globally been detected in house dust[67 68 69 70 66](Franzblau et al. 2009; Takigami et al. 2008; Suzuki et al. 2006; Ma et al. 2009; Suzuki et al. 2010). Japan is the first country to have performed a more systematic screening of total dioxin-like compounds in house and office dust[66] (Suzuki et al. 2010). It was found that PBDF are the major contributors to dioxin-like toxicity in this particularly relevant exposure matrix. Suzuki showed that dioxin-like PBDF toxicity considerably exceeded the combined amount from chlorinated PCDD, PCDF and dioxin-like PCBs in the samples from 19 households and 14 offices/laboratories[66] (Suzuki et al. 2010).

The bio-TEQ levels in these dusts were up to 1,400 ng (median 160 ng) CALUX-TEQ/kg. These levels are three to five orders of magnitude higher than those in food samples. As there was a difference of approximately three orders of magnitude for dioxin-like PCBs and PBDD/DF concentrations in these indoor dusts Suzuki concluded that this indicated the specific source of PBDD/PBDF as the indoor environment[66] (Suzuki et al. 2010).

An assessment of daily intake of dioxin-like compounds for children (1-5 years) revealed a significant contribution to daily intake from dust even for a moderate intake scenario of 50 mg dust/day. A simple calculation for the highest concentration shows that a child could be ingesting 280 pg TEQ/day. Child specific exposure factors from United States Environmental Protection Agency (US-EPA)[71] show that the mean bodyweight over this age range is between approximately 11 kg at 1 year to 19.5 kg at 5 years. Consequently the daily intake can range from about 14 to over 25 pg/kg bw/day from dust alone. These exposures far exceed of the WHO and European Tolerable Daily Intakes for chlorinated dioxins. For a high dust exposure scenario of 200 mg dust/day and median dust concentrations levels the daily

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[67] Franzblau, A.,Demond, A.,Towey, T.,Adriaens, P.,Chang, S.C.,Luksemburg, W.,Maier, M.,Garabrant, D.,Gillespie, B.,Lepkowski, J.,Chang, C.W.,Chen, Q. Hong, B., (2009). Residences with anomalous soil concentrations of dioxinlikecompounds in two communities in Michigan, USA: a case study. Chemosphere 74(3): 395-403

[68] Takigami, H.,Suzuki, G.,Hirai, Y. Sakai, S.-i., (2008). Transfer of brominated flame retardants from components into dust inside television cabinets. Chemosphere 73(2): 161-169

[69] Suzuki, G.,Nose, K.,Takigami, H.,Takahashi, S. Sakai, S.-I., (2006). PBDE and PBDD/Fs in house and office dust from Japan. Organohalogen Compounds 68

[70] Ma, J.,Addink, R.,Yun, S.,Cheng, J.,Wang, W. Kannan, K., (2009). Polybrominated Dibenzo-p-dioxins/Dibenzofurans and Polybrominated Diphenyl Ethers in Soil, Vegetation, Workshop-Floor Dust, and Electronic Shredder Residue from an Electronic Waste Recycling Facility and in Soils from a Chemical Industrial Complex in Eastern China. Environ Sci Technol 43(19): 7350-7356;

[71] Environmental Protection Agency (US), Child-Specific Exposure Factors 2002, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243#Download

intake of dioxin-like compounds of children via dust exceeded the daily intake of TEQ from PCDD/PCDF via food[72] (Suzuki et al. 2007):

6.11.8 Conclusion on assessment of end-of-life treatment of flame retardant containing electronics (and other flame retarded materials)

In conclusion, the end-of-life management of imaging equipment, in which brominated aromatic substances are used in plastics, entails health and environmental risks.

- Plastic containing brominated aromatic substances has a negative influence on the recycling of imaging equipment as the plastic fraction containing BFR needs to be removed from any separately collected WEEE and disposed of or recovered with specific requirements based on the provisions of Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). Difficulties on WEEE are presented in more detail in Annex 6.12.3.
- A large proportion of brominated flame retarded materials are combusted. Depending on the quality of combustion, high levels of brominated dioxins and furans can be formed and released as a result of the dioxin precursor properties of aromatic brominated flame retardants. In particular, open burning of e-waste is estimated to globally generate PBDD/PBDFs and PXDD/PXDFs on a scale of tons and for many geographical areas can be considered as common practice (see also section 6.11.4). The toxicity and environmental concerns related to dioxins and furans are high (see section 6.11.6). Brominated flame retardants in plastics can be destroyed with high efficiency only if the plastics are treated in incinerators constructed and operating according to best available technology (BAT) and best environmental practices (BEP). However, in this case costs per ton of incinerated material are considered high (in the order of $100/t).
- Additionally, a large portion of Bromintaed FR-treated products end up in landfills and there is growing evidence and concern that brominated flame retardants including POPs/PBDEs are leaching from landfills and contaminating the environment in industrial countries as well as in developing/transition countries. Only in engineered landfills with bottom liners, leachates that escape to the environment can be collected and treated to reduce the flow of contaminants to ground and surface water for some

[72] Suzuki, G.,Takigami, H.,Nose, K.,Takahashi, S.,Asari, M. Sakai, S.i., (2007). Dioxin-Like and Transthyretin-Binding Compounds in Indoor Dusts Collected from Japan: Average Daily Dose and Possible Implications for Children. Environ. Sci. Technol. 41(4): 1487-1493

time but such treatments are expensive and not state-of-the art. Because of their persistence, POPs/PBDEs will remain in landfills for many decades – and probably centuries and are expected to be eventually released to the environment as the landfill engineering systems (including basal and capping liners, gas and leachate collection systems) will inevitably degrade and lose their ability to contain the contaminants. Therefore, land filling does not appear to be a sustainable solution for long-term containment of brominated FR-treated materials (as presented in section 6.11.5).

The praxis showed that these substances can be avoided and resulting to avoidance of their associated environmental impacts thus Criterion 9 - Plastic parts point e is proposed.

6.11.9 Reference list for brominated flame retardants

The references used in Annex 6.11 regarding brominated flame retardants are presented in Table 16.

Table 16 Reference list for brominated flame retardants

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6.12 Information on waste streams for imaging equipment[73]

Information and data regarding the waste stream of imaging equipment follows.

Imaging equipment originating from households in EU-27 shall be collected following the provisions of WEEE Directive. In this frame imaging equipment waste streams are reported and statistics are kept in Eurostat. In these statistics imaging equipment are documented together with other IT equipment i.e. computers and laptops. A significant amount of electronic equipment which is primarily sold and used in EU-27 is exported as second hand products from EU-27 to third countries mainly from Africa and Asia. From a life cycle perspective the investigation of the environmental impacts of end-of-life phase of these products shall also be captured. In life cycle assessments the boundaries of the product life cycle system has no restrictions based on the geographical origin in which the environmental impacts may occur. Further, numerous environmental considerations are associated with the end-of-life management of the imaging equipment whose are shipped out from EU-27 as in the destination countries the recycling facilities, the thermal treatment (i.e. uncontrolled burning) or the land filing does not meet the European health and environmental standards.

6.12.1 Waste streams within the geographical area of EU-27

The WEEE Directive currently sets a minimum collection target of 4 kg per year per inhabitant for WEEE from private households. This target was originally based on estimates made by the EU Priority Waste Stream project group that future quantities of WEEE are expected to be over 20 kg per person per year, of which the consumer sector accounts for 12 kg, the industrial sector for 5 kg, and the cables sector for 3 kg. No collection target was set for non-household WEEE.

Based on the study on WEEE of 2008 for DG ENV[73], currently in Western Europe the amount of WEEE produced per person is estimated to be higher than in the new Member States in which the amounts are substantially lower, but expected to rise in the future. A general characteristic of current collection rates is that these are, in the majority of Member States, far below 100% of the goods sold many years ago. Increasing collection is therefore

[73] Huisman, Jaco, Delgado Clara, Magalini Federico, Kuehr Ruediger, Maurer, Claudia Artim, Eniko Szlezak, Josef Ogilvie, Poll Jim, Steve Abs, final Report for DG ENV, 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE), United Nations University, 2008

one of the key issues to enhance the effectiveness of WEEE and to achieve the original intent of the Directive.

The new estimate[73] of the expected waste of electric and electronic equipment (WEEE) arising across the EU27 is between 8.3 and 9.1 million tonnes per year for 2005. This increase is due to expansion of the EU, growth in the number of households and inclusion of items that may have been excluded previously (B2B). Forecasts models predict that by 2020, total WEEE arisings will grow annually between 2.5% and 2.7% reaching about 12.3 million tonnes. Out of them 8.0% is allocated to the category of IT and Telecom excl. CRT's, in which imaging equipment are classified together with computers which makes 664 to 828 thousand tonnes for 2005 and 984 thousand tonnes in 2020. The estimate for imaging equipment is 268 thousand tonnes for 2008 as given in Table 17. These values are higher than the collected volumes reported in Eurostat (given here in Table 18-Annex 6.10.) which reach just in 2008 the 539,833 tonnes.

Table 17 Imaging equipment placed in the EU25 expressed in weight in tonnes[73]

Weight (tonnes)	2004	2005	2006	2007	2008
B&W laser printers	56,310	55,230	55,710	55,425	55,635
Colour laser printers	20,070	25,020	26,190	29,310	30,570
B&W copiers	50,950	54,000	52,000	50,500	47,500
Colour copiers	13,700	14,300	16,300	17,200	17,900
Inkjet printers & MFDs	109,010	112,185	113,575	115,435	116,780
Total	250,040	260,735	263,775	267,870	268,385

Table 18 Eurostat data for WEEE collected for IT and telecommunications equipment (including imaging equipment) in tonnes

IT and telecommunications equipment (including imaging equipment) waste collected (in tonnes per year

GEO/TIME	2005	2006	2007	2008
Belgium	10,673.94	12,155.19	14,372.85	16,284.71
Bulgaria	:	:	3,835.72	4,553.71
Czech Republic	:	:	7,270.9	9,784.1
Denmark	:	11,380	17,043	16,507
Germany (including former GDR from 1991)	:	102,336	117,749	155,007
Estonia	:	687.04	870.71	970.7
Ireland	:	:	11,163	9,599
Greece	449	1,001	2,981.53	5,941.94
Spain	:	:	14,406	17,019
France	:	8,540	28,574	47,766
Italy	:	:	:	:
Cyprus	263.6	856.9	127.62	290.11
Latvia	:	:	800.78	853.48
Lithuania	288	1,072	1,575	1,415
Luxembourg	:	570.18	852.94	827.51
Hungary	1,242	2,377.8	3,472.5	5,719.1
Netherlands	16,838	18,440	21,049	23,069
Austria	3,148.2	11,365.5	13,212	15,342.8
Poland	:	3,067.3	8,714.74	14,948.73
Portugal	:	1,175.65	3,238.15	11,937
Romania	:	274.24	1,164.32	6,252.69
Slovenia	:	:	:	:
Slovakia	285.65	857.9	2,101.01	2,532
Finland	2,841	7,012	10,375	11,647
Sweden	9,440	25,174	29,782	29,556
United Kingdom	:	:	55,831.34	132,009.89
Malta	:	:	:	:
EU-27 Total	45,469	208,343	370,563	539,833

: not available

The EU15 Member States' average collection performance is roughly half that of Switzerland and Norway. This is mainly due to lower performance in the collection of categories other than the category referring to large household appliances. Although the WEEE Directive collection target can be easily met by EU15 Member States, it remains a very challenging target for the New Member States[73].

The estimated amount of WEEE currently collected and treated as a percentage of the amounts of WEEE arising for the EU27 in 2005 for the category in which imaging equipment are covered is 27.8%. There is no information available on differences between imaging equipment and computers as these are not differentiated in Eurostat categories but it is suggested that there shall be no large differences.

This means that for computers and imaging equipment there is substantial room for improvement (up to 70 %) of the waste stream covered by WEEE Directive. Further, it is important to highlight that there were identified large differences in performance by different Member States per sub-category which indicates that there is much room for improvement in collection performance[73].

Regarding impacts of WEEE for metals there appear to be no major difficulties concerning the recovery and recycling for metals. On the contrary for plastics data from literature seems to confirm that at present plastic output streams from WEEE recycling operations are mostly not recovered, but are landfilled together with other residue streams, as opposed to the apparent preference for the recycling option.

Annex II of WEEE Directive requires that plastics containing brominated flame retardants are removed from any separately collected WEEE and are disposed of or recovered in compliance with Article 4 of Council Directive 75/442/EEC on Waste.

It is suggested that the removal obligation reduces the amount of plastics available for recycling and hinders the meeting of recycling targets in some plastic dominated WEEE categories. Further, recycling of BFR plastics into non electronic and electric applications (houseware, automotive, building…) can cause dispersion of additives into other diverse streams, which could be interpreted as against the principle that recovery should ensure that pollutants are not transferred into products and minimises the formation, transfer and dispersion of hazardous substances in the process.

6.12.2 Waste streams outside the geographical area of EU-27

It is considered that a high number of EEE including imaging equipment is exported from EU27 as reused products. This way the waste of these products is not handled and treated in EU27 (in which WEEE Directive is applicable) but in the destination countries in which often lower health and environmental standards are applied along the end-of-life phase of the products. Trade statistics to non EU Members embrace a part of the actual exports. However, statistics do not differentiate between used and new goods. Thus, capturing the actual volume of these products is difficult. In Eurostat exports outside EU27 of WEEE are reported to be either zero or in marginal amounts compared with the overall arising of waste of EEE.

As this issue has gained awareness a study for the German Federal Environmental Agency regarding the trans-boundary shipment of waste electrical and electronic equipment / electronic scrap was conducted in 2010 [74]. This report describes approaches, measures and regulation structures for the export of used electrical/electronic equipment and waste electrical/electronic equipment to non-EU countries with aim to optimise the protection of the environment and resource flows. Volumes on used imaging equipment shipped in 2008 from the port of Hamburg to Ghana, Nigeria, South Africa, Vietnam, Philippines and India.

The export of the equipment types investigated in non-EU countries took place exclusively as used equipment. However, the value of these products which are exported for reuse lies significantly below the value compared with the respective items exported to Member States. Notified waste exports of such equipment is not known. In general the equipment originates from a multiplicity of sources (in all >4,000 sources), in part from private end users, in part from commercial sources and partially from the waste regime.

Private collection and reloading points represent one of the most important pivotal points for the export of low-value equipment. In the countries of destination, the equipment encounters recovery and disposal structures, which are not suitable to ensure the protection of human

[74] Knut Sander, Stephanie Schilling for the Federal Environment Agency (Germany), "Transboundary shipment of waste electrical and electronic equipment / electronic scrap – Optimization of material flows and control", Ökopol GmbH, 2010
http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3933

health and the environment as well as the extensive recovery of resources. Through this, several hundred of kilos of precious metals and rare earths are lost from the economic cycle.

The total quantity of the exports extrapolated within the framework of the investigation from German Federal Agency in 2008 lay between 93,000 t and 216,000 t. In the countries of destination, the equipment encounters recovery and disposal structures, which are not suitable to ensure the protection of human health and the environment as well as the extensive recovery of resources.

As found in Table 19 for imaging equipment the largest amount 5.154 tonnes was shipped from Hamburg to South Africa while 2.875 tonnes to India, 754 tonnes to Vietnam 722 tonnes to Nigeria and lower amounts to Philippines and Ghana 178 tonnes and 106 tonnes respectively. In total the amount of imaging equipment shipped as reused items towards countries in which the end-of-life facilities are not meeting the health and environmental standards of EU in one year and only from the port of Hamburg was 9,789 tonnes.

Table 19 Export from Germany to select countries of destination (reference year 2007)[74]

Goods code	Plaintext	Ghana	Nigeria	South Africa	Vietnam	Philippines	India
		Weight in t					
WA8415	Air conditioning units	33	32	778	83	46	525
WA8418	Refrigerators, freezers, heat pumps	64	312	791	169	24	517
WA8443	Printing machines and accessories for printing machines	106	722	5.154	754	178	2.875
WA8450	Machines for washing or drying clothes	22	19	358	19	27	49
WA8469	Typewriters, word processing machines	1	-	-	0	1	1
WA8471	Automatic data processing machines	56	152	782	170	24	108
WA8510	Razors, shears with electric motor	0	-	25	-	0	1
WA8516	Electric hot water heaters and immersion heaters	20	56	1.106	3	85	68
WA8517	Telephone sets, telecommunication equipment	10	478	1.234	116	34	1.737
WA8521	Audio/video recording equipment	1	60	6	0	0	0
WA8525	Transmission equipment for broadcast etc., television cameras	1	56	64	24	3	25
WA8527	Receiving equipment for radiotelephone traffic or broad-cast	1	4	149	0	0	10
WA8528	Television sets, video monitors	153	787	145	802	1	129
Total		**468**	**2.678**	**10.592**	**2.140**	**423**	**6.045**

6.12.3 Difficulties of plastics recycling from WEEE

Number of facilities which can separate plastics in the EU including separation of BFR plastic Whilst there are several WEEE recycling plants in Europe using 'state-of-the-art' technologies for the separation of plastics, there are still only a handful of facilities for comprehensive treatment integrating plastic separation and recycling, and only a very few plants separate BFR-containing plastic[75]. Most WEEE recycling companies dismantle and sort equipment into various streams and then pass the plastic rich fraction to other specialised operators. Some aim for the recovery of residual metals in these polymer-rich fractions, others recycle parts of the plastic fraction, a third group recovers energy and a proportion of WEEE plastics are sold as mixed plastic for export - mainly to China[75]. Only about 8 % of plastic from WEEE is recycled[76,77].

Reasons for the limited recycling of WEEE plastic

The four main reasons for the limited number of approaches for recycling plastics from WEEE are included below[75]:

a) Industry using secondary plastic materials has tight specifications in relation to polymer quality, both chemically (RoHS compliance) and with respect to material properties. This is also used as an argument to depress the prices of recyclate thus increasing the economic challenges.

b) WEEE plastics contain at least 15 different plastic types (Dimitrakakis et al. 2009, UNEP 2011). The efficient sorting of this mixture presents difficult technical challenges and a degree of cross-contamination is inevitable in practice. According to Dimitrakakis[77] three polymers (ABS, PS, PP) account for between 70 % and 85 % of total while other studies estimate that this fraction is a bit lower at 50-70%.

c) WEEE plastics contain RoHS listed BFRs (PentaBDE, OctaBDE, DecaBDE; but normally no PBB which is also listed). Potential customers are therefore risk adverse to contaminated recyclate.

d) Production of larger volumes with identical properties and performance, as required by many major manufacturers, requires consistent quality and composition of inputs.

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75 UNEP (2010) Technical review of the implications of recycling commercial penta and octabromodiphenyl ethers. Stockholm Convention document for 6th POP Reviewing Committee meeting (UNEP/POPS/POPRC.6/INF/6) Geneva 11-15. October 2010.

76 UNEP (2011). Guidance on the Best Available Techniques (BAT) and Best Environmental Practice (BEP) for recycling and waste disposal of articles containing POP-PBDEs. Draft 10/2011.

77 Dimitrakakis E., Janz A., Bilitewski B. Gidarakos E. (2009) Small WEEE: Determining recyclables and hazardous substances in plastics. Journal of Hazardous Materials 161(2-3): 913-919

Japan has already established a Japanese Industrial Standard (JIS) for plastics for use in electric home appliances, "*marking for identification of plastic parts for electrical and electronic equipment (C9912).*" This standard requires the marking of plastic parts such as flame retardants (FR), recycled plastics and dismantling assistance. In particular, the marking system includes plastics already recycled by 'closed-loop recycling' (i.e. recycling within the same product group). Target recycling rates for different electronic categories have also been set[78] (Aizawa et al. 2010).

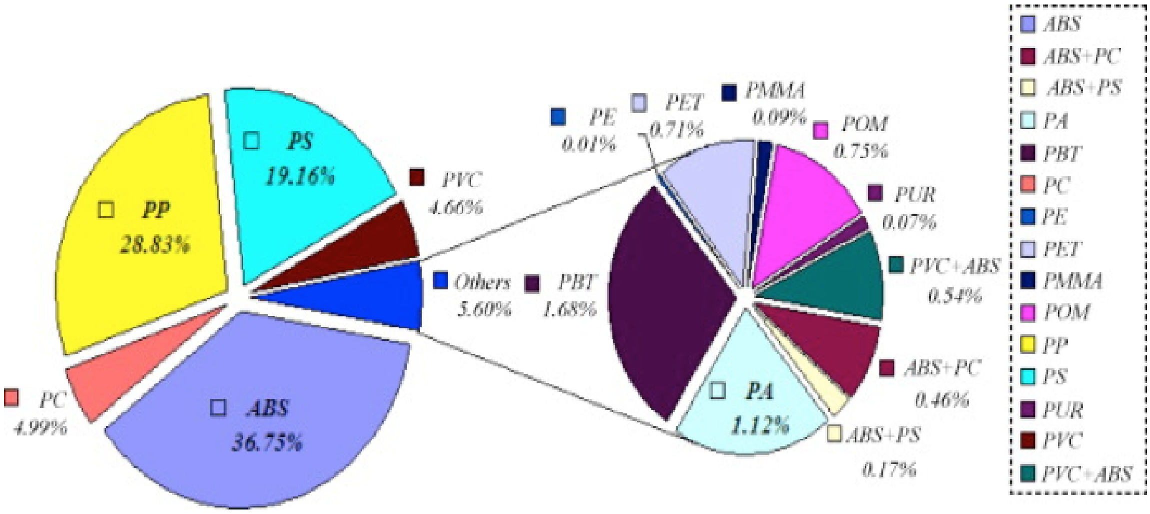

Figure 1: Polymer types identified in WEEE plastic samples (%, w/w)[77]

[78] Aizawa H., Hirai Y., Sakai S.-I. (2010) Development of Japanese Recycling Policy for Electric Home Appliances by the Addition of Plastics Recycling. BFR2010: 5th International Symposium on Brominated Flame Retardants. 7.-9. April 2010, Kyoto/Japan

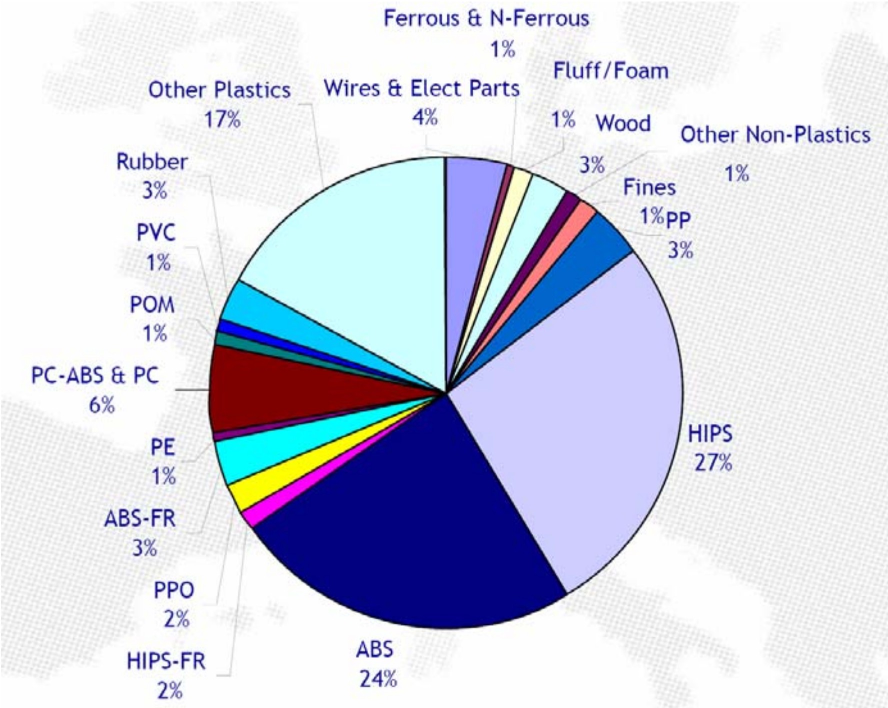

Figure 2: Polymer types and other materials identified in WEEE plastic samples (%, w/w)[76]

6.13 Information regarding the end-of-life considerations of PVC

A key concern regarding PVC is at end-of-life management. The management of PVC waste should be assessed in the context of the European waste management policy. The Communication from the Commission on the review of the Community strategy for waste management[45] has confirmed *"the hierarchy of principles that prevention of waste shall remain the first priority, followed by recovery and finally by the safe disposal of waste."* It is further stated that *"preference should be given, where environmentally sound, to the recovery of material over energy recovery operations. This general rule is based on the fact that material recovery has a greater effect on waste prevention than energy recovery. It will nevertheless be necessary to take into account the environmental, economic, and scientific effects of either option. The evaluation of these effects could lead, in certain cases, to preference being given to the energy recovery option."* In its Resolution[46] of 24 February 1997, the Council endorsed this hierarchy of principles.

The three main options for end of life management of materials containing PVC are: (1) reuse/recycling (2) incineration/thermal treatment (3) deposition. Management of end-of-life waste flows can vary widely based on the type of waste management schemes used in various countries and the different materials involved (PVC in mixed plastic fraction; PVC as; PVC in hospital wastes).

6.13.1 Mechanical recycling of PVC and PVC containing materials

Mechanical recycling refers to recycling processes where PVC waste is treated only mechanically, mainly through shredding, sieving, and grinding. From a life cycle perspective, the preferred method for end-of-life treatment of PVC and PVC containing wastes would be mechanical recycling because it reduces the energy-intensive production of new materials.

A number of life cycle assessments[49] on some specific PVC products have shown that mechanical recycling provides an environmental advantage for production waste, cut-offs and post-consumer PVC waste, which can be separated. The environmental advantages of the down-cycling of mixed plastics for the production of products which substitute concrete, wood or other non-plastic applications are less certain.

However, the presence of additives classified as hazardous, such as lead, cadmium and PCB, in large PVC waste streams, raises specific issues during their potential recycling. The recycling of PVC waste containing heavy metals results in a dilution of these substances in a greater quantity of PVC, since it is necessary to add virgin material. The heavy metals are not directly released into the environment during the recycling process and the renewed service life. The recycling of PVC material containing these heavy metals postpones the final disposal to a later stage. Due to the product-specific additives formulations, recyclers would prefer recycling into similar applications.

A prohibition of the recycling of PVC waste containing heavy metals would eliminate the mechanical recycling of post-consumer PVC wastes from building applications - the waste stream with the highest potential for high-quality recycling - as they virtually all contain lead or cadmium. It should be noted that, except for Denmark, Member States, which have banned the use of cadmium as stabilisers, allow the recycling of PVC waste containing cadmium.

The problem of PCBs in PVC cable waste has been addressed in Directive EC/96/59 on the disposal of PCB and PCT, which states that cables containing more than 50 ppm of PCBs are considered PCBs and therefore have to be decontaminated or disposed of in accordance with the provisions established under this Directive.

The resulting recyclates (in powder form) can be processed into new products. Depending on the degree of contamination and the composition of the collected material, the quality of the PVC recyclates can vary to a large degree. The quality of the recyclates determines the degree to which virgin material can be substituted by recyclates: “high-quality” recyclates can be reused in the same types of PVC applications, whereas “low-quality” recyclates from mixed waste fractions can only be “down-cycled” into products usually made from other material (EC 2000).

In the baseline scenario presented in the PVC green paper about 9 % of the total PVC waste could be mechanically recycled in 2010 and 2020, representing about 400 000 tonnes of PVC waste in 2010 and 550 000 tonnes in 2020 (EC 2000, Prognos 2000). Compared to this baseline scenario, maximum recycling potentials, which represent the PVC quantities which can be recycled (taking into account the technical and economic limits of PVC) recycling have been estimated by Prognos in 2000 (EC 2000). According to this scenario, the potential for post-consumer waste was estimated to about 800 000 tonnes in 2010.

However the recycling quota of PVC today demonstrates that PVC recycling is still a major challenge. According to the estimates of the Vinyl Institute *“it is anticipated that the total* *recycled will reach up to 200 000 tons of PVC waste in 2010*"[79] only 4 % of thr PVC waste amount for 2010 will be recycled.

The largest part of the remaining 96 % of the PVC wastes goes to landfills and some of the waste into incineration. The suggested recycled amount would therefore be only 50 % of the baseline scenario and only 25 % of the estimated maximum recycling potential projection from the Commission in the 'Green Paper – Environmental Issues of PVC' (EC 2000). The Vinyl Institute states that this small recycling quota would only be reached with governmental support '*For this recycling volume to be reached there is a need for support from public authorities to create and organise appropriate waste collection schemes*' (Vinyl 2010). This means that governmental support in collection (which is the most expensive part of recycling) is a precondition even for a 4 % recycling quota.

According to the EC Green Paper, the recycling of PVC is also limited by the overall recycling costs (EU 2000) which is probably the main driving force for the low recycling quota. Economic profitability is reached when the net recycling costs (i.e. the overall costs for collection, separation and processing minus the revenues from sale of the recyclates) are lower than the prices for alternative waste management routes for related PVC wastes. The EC further states that *'If economic profitability cannot be reached, the recycling of PVC waste will not take place under free market conditions, unless there are legal obligations or voluntary measures enforcing or promoting the recycling of PVC. Collection represents the major bottleneck regarding the availability of waste and costs.'*

For PVC in electronics like imaging equipment, the sorting cost would add to these expenses. Cable insulation is the only post-consumer waste which can be recycled at competitive costs, due to the presence of valuable metals, such as copper (EC 2010). High-quality mechanical recycling of PVC for post-consumer wastes is considered to be in a preliminary stage and in 2000 existed only for few product groups and with low quantities (about 3.600 tonnes of rigid profiles, 5,500 tonnes of PVC pipes and 550 tonnes of flooring) (EC 2000).

In respect of the use of PVC in articles which finally generate a mixed plastic fraction (like electronics including imaging equipment), the EC paper concludes that PVC can have a negative influence on the recycling of other plastics in mixed plastic waste (EC 2010): '*When*

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[79] Vinyl 2010, Reporting of the activities of the year 2010 and summarising the key milestones of the past 10 years, The European PVC Industry's Sustainable Development Programme, http://www.vinyl2010.org/images/progress_report/2011/vinyl2010_progress_report_2011_final.pdf

PVC is processed with other plastics, such as in the packaging waste stream, the processing temperature is limited to the range of PVC-processing, which is a relatively low range compared to other plastics. Due to similar densities, polyethylene terephthalate (PET) and PVC waste are difficult to separate and the presence of PVC puts additional costs on some PET recycling schemes such as the PET bottles.' (EC 2010). This is an important consideration for restriction of PVC in electronics such as imaging equipment.

6.13.2 Chemical recycling of PVC and PVC containing materials

Chemical recycling denotes a number of processes, by which the polymer molecules that constitute plastic materials are broken up into smaller molecules. These can either be monomers that can be used directly to produce new polymers or other substances that can be used elsewhere as starting materials in processes of the basic chemical industry.

In the case of PVC, in addition to the breaking up of the backbone of the polymer molecules, the chlorine attached to the chains is set free in the form of hydrogen chloride (HCl). Depending on process technology, HCl can be reused after purification or has to be neutralised to form various products that can be used or have to be disposed of (EC 2000).

For 2010, the total PVC waste quantities which could be chemically recycled in the baseline scenario, were estimated to about 80 000 tonnes as a fraction in mixed plastics waste with low chlorine content (mostly from packaging) and about 160 000 tonnes in mixed plastic fractions with higher PVC content, mostly from automotive and electric and electronic waste (EC 2000).

6.13.3 Incineration/thermal treatment of PVC

6.13.3.1 Negative impact of PVC in cement kilns

PVC has a crucial negative impact on the incineration and thermal recovery of polymer waste in cement kilns. PVC (and other halogenated material) limits or even restricts the use of thermal recycling in cement plants which normally accept polymer waste as secondary fuel up to a chlorine content of 0.5 %. In the best available techniques reference documents on cement, lime and magnesium oxide manufacturing industries[80] is reported in the BAT chapter that in order to reduce HCl emission the producer has to use a) raw materials and fuels containing a low chlorine content, b) limit the amount of chlorine content for any waste that is to be used as raw material and/or fuel in a cement kiln. Moreover, cement quality composition specification included limitation of chlorine content due to corrosion problems that may occur in the concrete reinforcement.

6.13.3.2 Negative impact of PVC in waste incinerators

An assessment of the quantities of flue gas cleaning residues resulting from the incineration of PVC waste concluded that the incineration of 1 kg of PVC generates on average[59] between 1 and 1.4 kg of residues for the dry process with lime, semi-dry and semi-wet wet processes (Bertin technology 2000). With the use of sodium hydrogen-carbonate as a neutralisation agent in semi-dry process, 1 kg of PVC generates about 0.8 kg of residue. In case of wet processes, between 0.4 and 0.9 kg of liquid effluent is generated[81].

These flue gas cleaning residues are classified as hazardous waste (EC 1994). The residues are generated separately (in particular in semi-wet and wet systems) or mixed with fly ash. The residues contain the neutralisation salts, the excess neutralisation agent as well as pollutants such as heavy metals and dioxins that were not destroyed. Landfilling of the residues is, with some exceptions, the only option used within the Member States. Several processes have been devised to recover calcium chloride and sodium chloride from the residues of the dry and semi-dry processes, but few of them are currently used commercially. The EC highlighted that these technologies are “end of the pipe” solutions, less preferable than a preventive measure aimed at reducing at source the quantity of residues generated (EC 2000).

Therefore - for the treatment in BAT incineration, the minimization of PVC input should be considered.

In summary, PVC at in the municipal solid waste stream has the following effect on the flue gas cleaning residues in comparison to incineration of municipal solid waste without PVC[63]:

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[80] European Commission, Best available techniques reference documents on cement, lime and magnesium oxide manufacturing industries, Joint Research Centre, Institute for Prospective Technological Studies, IPPC bureau, 2010

[81] . There is a difference between the amounts of neutralisation agent required and residues produced between soft and rigid PVC. Flexible PVC contains less chlorine than rigid PVC. The amounts of neutralisation agents required and of residues generated are therefore lower for flexible PVC than for rigid PVC (1 kg of soft PVC generates between 0.5 and 0.78 kg of residues) (Bertin Technology 2000).

- PVC incineration contributes to an increase in the quantity of flue gas cleaning residues (about 37 % for the dry systems, 34 % for semi-dry systems and 42 % for semi-wet wet 64);
- PVC incineration contributes to an increase in the content of leachable salts in the residues by a factor of two. These are primarily chlorides of calcium, sodium, and potassium;
- The incineration of PVC increases the amount of leachates from the residues put into landfill (about 19 % for dry systems, 18 % for semi-dry systems, 15 % for the semi-wet wet systems and 4 % for wet systems). The leachates need to be treated prior to any discharge.

Furthermore PVC waste incineration increases the operating costs of the incinerators due to the use of neutralisation agents to neutralise the acid flue gas, and adds additional costs for the waste management of the resulting residues. Up to EUR 300 per tonne for dry systems (Bertini et al 2000). These additional costs are not borne specifically by new PVC products or by PVC waste, but are included in the overall incineration cost of waste. A reduction of PVC waste would have a positive effect on this.

6.13.3.3 PVC and PCDD/F formation in thermal processes

The question on the role of PVC in the formation and release of PCDD/PCDF in combustion raised awareness since many years now (many references go back to 1999). A similar situation exists for combustion of PVC-containing materials as described for brominated flame retardants in Table 7.

State of the art municipal waste incinerators can treat PVC containing waste (up to 1 % chlorine) and hazardous waste incinerators (wastes above 1 % chlorine) without a significant increase in PCDD/PCDF formation, since the limiting parameter for PCDD/PCDF de novo synthesis in the cooling zone is not chlorine (which in fly ashes is about 10%), but carbon (which in BAT incineration ash is at levels well below 1 % or even 0.1 %).

However for small scale incinerators and non-BAT incinerators with lower combustion efficiency, carbon levels (products of incomplete combustion) are high, and the chlorine content (with PVC as main contributor) is the determining factor for PCDD/PCDF formation and release. PCDD/PCDF formation and release has a strong correlation to the PVC content, which is the major driver for high PCDD/PCDF emission levels (Ibashi 2011).

PVC products disposed of in landfills contribute to the formation of dioxins and furans during accidental landfill fires (EC 2000). The release of PCDD/PCDF from landfill fires and open burning is one of major PCDD/PCDF sources in the national inventories established under the Stockholm Convention. Of particular interest in respect to EEE (including imaging equipment) is the high release of PCDD/PCDF in primitive WEEE recycling in developing countries: it has been shown for e-waste recycling sites in China that PVC was the main source of PCDD/PCDF environmental contamination, while the brominated flame retardants were the main source for the brominated and chlorinated-brominated PXDD/PXDF (Zennegg et al 2009). Since the EU is party to the Stockholm Convention, unintentional POP releases need to be minimised, and the substitution approach applied. Similar considerations where made in the development of the criteria establishment by the Nordic Swan[82].

6.13.4 Deposition of PVC in landfills

Deposition in landfills is the most common waste management route for PVC waste. It can be estimated that several tens of million tonnes of PVC waste have already been sent to landfills during the past 30 years.

All materials in landfills including PVC are subject to different reactive conditions, which are determined by parameters such as temperature, moisture, presence of oxygen, activity of micro-organisms and the interactions between parameters at different stages of the ageing process of landfills[83].

Investigations have been carried out on both rigid and soft PVC samples mainly through laboratory equipment studies, examination of the effects of biological treatment, and of microbiological tests (Argus 1999).

The PVC polymer is generally regarded as being resistant under soil-buried and landfill conditions (Mersiovski et al 1999). However, an attack on the PVC polymer of a thin packaging foil has been detected (Argus 1999). This remains an isolated result and the

[82] Nordic Swan (2007)": The Nordic countries are bound by the Stockholm Convention on Persistent Organic Pollutants (POPs) to omit waste containing POPs at source so that POPs are destroyed or pacified without impacting the environment (www.pops.int). The convention considers the incineration of PVC, for example, to be a source of POPs, in particular dioxins". (Nordic Swan 2007) "Furthermore, there is always a risk of POP emissions (dioxins) from uncontrolled fires that involve PVC and other materials containing chlorine, e.g. houses, hotels and hospitals". (Nordic Swan 2007).

[83] Four main phases can be distinguished: short initial aerobic phase, anaerobic acidogenic phase (variable duration, longer than aerobic phase), anaerobic methanogenic phase (up to several centuries), final aerobic phase.

attack was observed under aerobic conditions and at 80°C, conditions which, if they occur in landfills, are transient.

Losses of plasticisers, especially phthalates, from flexible PVC are widely recognised in the literature (EC 2000). Results from studies on the degradability of phthalates under landfill conditions show that degradation of phthalates occurs, but may not be complete depending on conditions and type of phthalate. Both phthalates and their degradation substances can be detected in landfill leachates (EC 2000). In addition, long-chain phthalates, such as DEHPs, are only partly degraded in usual leachate and sewage treatment plants and accumulate on suspended solids. Losses of phthalates could also contribute to gaseous emissions from landfills. As for other emissions from landfills, emissions resulting from the presence of PVC in landfills can last longer than the guarantee of the technical barrier, and there is no evidence that the release of phthalates will end after a given period of time.

A study into the long-term behaviour of PVC waste under landfill conditions showed a release of lead stabiliser from flexible PVC waste (Mersiowski et al 1999). Stabilisers in rigid PVC waste are more encapsulated in the matrix. Hence, migration is expected to be lower in rigid PVC and would mainly affect the surface of the PVC. The effect on the bulk of the material is uncertain.

As mentioned above, PVC products disposed of in landfills contribute to the formation of dioxins and furans during accidental landfill fires (EC 2000). The release of PCDD/PCDF from landfill fires and open burning is one of major PCDD/PCDF sources in the national inventories established under the Stockholm Convention.

6.13.5 Conclusion on the assessment of end-of-life treatment of PVC

The PVC recycling quota is very low. Based on the prediction of vinyl2010[84] the recycling quota of PVC would be only 4% of the total PVC waste amount for 2010. This recycled amount would be only 50 % of the baseline scenario estimated from the Commission in the "Green Paper – Environmental Issues of PVC". Even for this small recycling quota,

[84] Vinyl 2010 is the voluntary programme on Sustainable Development by the PVC industry. Vinyl 2010 represents the whole PVC industry chain. Its four founding members are: ECVM (the European Council of Vinyl Manufacturers), representing the 13 European PVC resin producing companies which account for almost 100% of the current total EU-27 PVC resin production, ESPA (the European Stabilisers Producers Association), representing 11 companies which produce more than 98% of the stabilisers sold in Europe, ECPI (the European Council for Plasticisers and Intermediates), representing the seven major European plasticiser and intermediate producers, EuPC (the European Plastics Converters) represents close to 50,000 companies in Europe, producing over 45 million tonnes of plastic products of various types every year.

governmental support in collection (which is the most expensive part of recycling) is a precondition.

PVC has a negative influence on the recycling of other plastics such as the recycling of mixed plastic waste (i.e. imaging equipment). As stated in the Green Paper for PVC, the processing temperature is limited to the range of PVC processing, which is a relatively low range compared to other plastics.

PVC (together with other chlorine containing polymers) has crucial negative impact on the incineration and thermal recovery of polymer waste in cement kilns. The presence of PVCs in mixed plastic waste fractions restrict the use of PVC containing waste as fuel in cement plants which normally accept polymer waste up to a chlorine content of 0.5%.

PVC has a negative impact in incineration plants which operate under BAT conditions, due to the high costs of the treatment of flue gas cleaning residues which are produced in increased volumes when PVC is present. Flue gas cleaning residues are classified as hazardous waste and their treatment is associated with high costs which are directly linked to the operational costs of the incinerator. As highlighted in the EC Green Paper for PVC, a preventive measure aimed at reducing the quantity of residues generated at source is more preferable than the treatments of them afterwards.

PVC-containing waste is associated with the formation of dioxins and furans in thermal processes with insufficient combustion conditions i.e. incinerators operating on non-BAT conditions, uncontrolled burning, accidental fires etc.

Deposition in landfills is the most common waste management route for PVC. Degradation of plasticisers used in PVC occurs in landfills, resulting to emissions both to leachates and to air. Environmental impacts are related to the release of these substances. Emissions from PVC can last longer than the guarantee of the technical barrier used in landfills.

6.13.6 Reference list related to the end-of-life environmental consequences of PVC[85]

AEA Technology, Economic evaluation of PVC waste management, a report produced for the European Commission Environment Directorate-General, June 2000.

Argus in association with University Rostock (1999) ,The Behaviour of PVC in Landfill, Study for DG ENV,

Bertin Technologies, The influence of PVC on quantity and hazardousness of flue gas residues from incineration, Study for DG XI, April 2000

European Commission (2000) GREEN PAPER Environmental issues of PVC; COM (2000) 469 final; Brussels, 26.7.2000.

Mersiowski et al. 1999, Behaviour of PVC in landfills, ECVM, Technical University Hamburg-Harburg

Prognos, Mechanical recycling of PVC wastes, Study for DG XI, January 2000

Vinyl (2010) REPORTING ON THE ACTIVITIES OF THE YEAR 2010 and summarising the key milestones of the past 10 years.

Zennegg, M.,Yu, X.,Wong, M.H. Weber, R., (2009). Fingerprints of chlorinated, brominated and mixed halogenated dioxins at two e-waste recycling sites in Guiyu/China. Organohalogen Compounds 71, 2263-2267

85 With regard to the formation of dioxin and furans see also references presented in section 6.11.9

6.14 Information regarding the green paper on environmental issues of PVC

The following questions and answers as published in the official website of the EU[86] related to the publication of the Green Paper on environmental issues of PVC[87] are presented as follows:

Green Paper on environmental issues of PVC

Reference: MEMO/00/46 Date: 26/07/2000

Brussels, 26 July 2000

Green Paper on environmental issues of PVC

QUESTIONS & ANSWERS

1. Why is the Commission taking an initiative on PVC?

The Green Paper follows the commitment of the Commission, made in its Proposal for a Directive on end of life vehicles[88].

The whole life cycle of PVC raises a number of environmental issues, in particular due to the use of certain additives (lead, cadmium and phthalates) and during the management of PVC waste.

Some Member States have recommended or adopted measures related to specific aspects of the PVC life cycle. These measures are not identical and some may have consequences for the functioning of the internal market.

PVC is one of the most widespread plastics used today with a production of about 5.5 million tonnes in Europe in 1998 (21 million tonnes world-wide, about 20 % of all plastics production). Overall production of PVC compounds (PVC resin and all additives) was at about 7.2 million tonnes in 1998.The economic weight of the industrial sector is important: the total PVC producing and transforming industry in Western Europe represents about 21,000 companies, 530 000 jobs and a turnover of more than 72 billion €.

2. What is PVC used for?

[86] Press release European Commission http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/00/46&format=HTML&aged=0&language=EN&guiLanguage=en

[87] European Commission, COM(2000) 469 GREEN PAPER Environmental issues of PVC http://ec.europa.eu/environment/waste/pvc/pdf/en.pdf

[88] Available online at: http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/00/46&format=HTML&aged=0&language=EN&guiLanguage=en#file.tmp_Foot_1#file.tmp_Foot_1.

The main applications of PVC in Europe today are in the building sector (windows, profiles, pipes, flooring), which accounts for 57% of all uses. The other largest uses are in the fields of packaging (9%), household (18%) and automotive appliances (7%).

3. The main distinction between the numerous applications is between « rigid PVC » (accounting for about two thirds of total use) and « flexible PVC » (accounting for about one third). The main uses of rigid PVC are pipes, window frames, other profiles, and parts of household appliances. Flexible PVC is mainly used in cables, flooring, as packaging material (flexible films), car under-floor protection and instrument panels for cars. What are the key figures for additive use and Waste quantities?

- About 1 million tonnes of phthalates are used annually as plasticisers to manufacture flexible PVC products. About 112,000 tonnes of lead stabilisers (containing about 51,000 tonnes of lead metal) were used in 1998 (overall consumption of lead for use in all kinds of products was 1.6 mill. Tonnes in Europe in 1997), 50 t of cadmium metal were used in 1170 tonnes of stabiliser formulations.
- About 3.6 million tonnes of post-consumer PVC waste are generated annually in Europe. An increase of PVC waste quantities of about 80% is expected in the coming 20 years. About 0.5 million pre-consumer waste (production and installation waste) is generated, 85% of which is recycled.

4. Why is the Commission only adopting a Green Paper and not a strategy with proposals for specific measures?

- The Green Paper is the first step towards the adoption of a Community strategy on PVC to be adopted in early 2001.
- The Commission wants to open a transparent consultation process to stimulate a debate on PVC. The European Parliament, the Member States, the NGOs, the Consumers, the industry have to be involved in this important issue.
- It is essential to launch a Europe-wide public debate on the basis of the fair and balanced analysis made in the Green Paper. Similar debates have already taken place in some Member States, but not in all of them.

5. Is it better to recycle, incinerate or landfill PVC?

- Currently about 3% of PVC waste is recycled (100,000 t), about 17% incinerated (about 600,000 t) and the rest landfilled (about 2.9 million t).

- The Green Paper gives a detailed analysis on the advantages and disadvantages of each of these options. On the basis of this analysis and given the present low recycling rate, the Commission considers that recycling of PVC should be increased. However, it is expected that recycling of PVC waste could contribute only to the management of about one fifth of PVC post-consumer waste. Other waste management routes will therefore remain important.
- The Green Paper presents the problems linked with the incineration of PVC and in particular the generation of residues from flue gas cleaning (classified as hazardous) due to of presence of chlorine in PVC.
- Concerning landfilling, the Green Paper discusses the stability of PVC under landfill conditions and the losses of phthalates from soft PVC, which are widely recognised in a number of published studies, but the quantities and the associated risks need to be assessed further.
- The Green Paper presents a number of potential measures to improve, in accordance with the general Community Waste Management Strategy, the management of PVC waste present in various waste streams and analyses the economic consequences of deviating PVC from incineration to recycling or landfill.
- It is too early to define a clear preference between incineration and landfilling for all types of PVC under all conditions. It is one of the purposes of the Green Paper to collect further information and the various opinions about this question.

6. What does the Commission think about the voluntary commitment of the PVC industry?

- The European PVC industry has signed a voluntary commitment on the sustainable development of PVC, which, *inter alia*, addresses the reduction of the use of certain heavy metal stabilisers, the mechanical recycling of certain post-consumer wastes, and the development of further recycling technologies.
- The Green Paper describes the content of this voluntary commitment and presents this initiative of the industry as one of the potential future options for the Community strategy on PVC.
- The signing and entry into force of this commitment (the implementation will start in 2001), which involves the complete industrial chain from producers to

transformers, represents an important step which needs to be assessed in function of the effectiveness criteria mentioned in the Communication of the Commission concerning agreements in the area of the environment (COM(96)561 final).

- The success of this approach will require a constant progression in the efforts realised in the specific areas covered by the agreement and, in particular, reduction in the production and use of certain additives, more ambitious target quantities for recycling, industry's contribution to added costs of incineration, and a fully operational funding mechanism.
- While this can be seen as a first step there is still work to be done to ensure an effective participation by industry in achieving Community goals in this area. It should be underlined that the services of the Commission are currently preparing a Proposal for a framework Regulation concerning Community environmental agreements to be adopted by Council and Parliament.

7. Is the Commission going to propose legislative instruments on PVC?

- There is a whole range of instruments available to address the environmental impacts of PVC, among them legislative measures, such as a Proposal for a Directive on PVC, or proposals for adaptation of various existing legal instruments. All possible options are mentioned in the Green Paper, together with questions regarding their effectiveness as well as their environmental and economic implications.
- The Commission expects that the contributions provided by the stakeholders during the public consultation process will give further indications on which strategy is the most appropriate.
- On the basis of the analyses developed in the Green Paper and the outcome of this consultation process, the Commission will present at the beginning of 2001 a Communication setting out a comprehensive Community strategy on the environmental issues of PVC. The strategy will set out all necessary measures, including, if appropriate, the development of proposals for legislative measures.

8. Is the Commission going to adopt measures concerning phthalates, lead and cadmium in PVC? Are there going to be risk assessments on these hazardous substances?

- In line with its general policy, the Commission will, in the light of a scientific and economic evaluation, propose and adopt all appropriate measures to address the use of these substances in PVC.

- Five phthalates have been included on the first three priority lists for risk assessment in accordance with Council Regulation 793/93 on the evaluation and control of existing substances. The risk assessments on these five substances are carried out by Member State rapporteurs (France, Sweden and The Netherlands respectively). The risk assessments on DEHP, DIDP, DINP, DBP have been or are expected to be completed in 2000 and in 2001 for BBP.
- It should also be noted that the specific risks due to the use of phthalates in certain soft PVC toys and childcare articles have been assessed by the Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE). On the basis of these opinions, the Commission has adopted on 10 November 1999 a Proposal for a Directive and on 7 December 1999 a Decision under the emergency procedure of Directive 92/59/EEC in order to ban of the use of phthalates in certain toys and childcare articles intended to be put in the mouth.
- Although at present no comprehensive risk assessments have been completed on the use of cadmium and lead compounds as stabilisers in PVC products, important work is already ongoing: a risk assessment is being finalised on cadmium and cadmium oxide under Regulation 793/93. For lead, the CSTEE has recently adopted an opinion regarding a draft ban on the use of lead in products in Denmark.
- The CSTEE is currently working on the issue of risks from the use of lead in general and an opinion, building *inter alia* on a study to be commissioned by the services of the Commission, should be adopted by mid-2001 on both the environmental and human health risks of lead.

9. What will happen after the Green Paper?

- In addition to the publication, the Green Paper will be transmitted to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. It will be published in the Official Journal and on the internet.
- A public hearing will be organised in October 2000. The targeted stakeholders are the general public as well as environmental and consumer NGOs, the

producers and transformers of PVC, the users of PVC (automobile, electronic, construction, distribution and packaging industries), as well as the public administrations of the Member States. The consultation period is scheduled to continue until the end of November 2000.

- On the basis of the analyses developed in the Green Paper and the outcome of this consultation process, the Commission will present, at the beginning of 2001, a Communication setting out a comprehensive Community strategy on the environmental issues of PVC to be implemented through various initiatives and measures.

10. Why is the Green Paper not focussing more explicitly on prevention and the substitution of PVC?

- Prevention is explicitly addressed on several occasions, in particular concerning the use of certain hazardous additives and recycling.
- The question of substitution is also explicitly addressed in the context of promoting more sustainable products as part of an Integrated Product Policy. Such a substitution policy could be considered for specific applications, which can not be easily separated from the general waste stream and therefore are difficult to recycle such as in packaging, motor vehicles, electric and electronic equipment.
- At present, PVC is competing with alternative materials for a number of applications. Given the large range of applications, often requiring a very specific technical performance, PVC cannot be replaced by one single material in all its applications. For each product type, potential substitute materials are different. These can either be other plastics such as polypropylene (PP) or polyethylene terephthalate (PET) in packaging, polyethylene (PE) and PP for construction applications, or other types of materials such as wood (e.g. for window frames) or concrete, cast iron for pipes
- It is stressed in the Green Paper that a potential substitution policy would need to be underpinned by a comprehensive and objective assessment of the main environmental impacts both of PVC and of potential substitutes during their whole life cycle. As the information on the environmental impacts of potential substitutes is generally scarce, the Green Paper at this stage cannot draw firm conclusions.

11. Why is the Green Paper only addressing environmental issues? Why not also human health concern?

- Firstly, the Commitment accepted by the Commission in 1997 and restated in 1999 concerned exclusively environmental aspects of PVC.
- Nevertheless, all related issues regarding human health that are known today have been addressed in the paper. In addition, as human health is mostly concerned indirectly through environmental impacts, the issue is (implicitly) taken into account.

12. What is the link between the PVC initiative and the integrated product policy approach which the Commission is developing?

- The PVC Initiative 'integrates' the basic principles of this approach, i.e. the examination of all issues from cradle to grave, as for other waste initiatives on packaging, end-of-life vehicles, WEEE and others have also already anticipated.
- The Commission has the intention to adopt a Green Paper on the Integrated Product Policy in 2000.

13. What About the Incineration of PVC and dioxin formation?

- The potential influence of the incineration of PVC waste on the emissions of dioxins has been at the centre of a major scientific debate since PVC is currently the largest contributor of chlorine into incinerators. The contribution of incinerators to the total emissions of dioxins in the Community was about 40% between 1993 and 1995.
- It has been suggested that the reduction of the chlorine content in the waste can contribute to the reduction of dioxin formation, even though the actual mechanism is not fully understood. It is most likely that the main incineration parameters, such as the temperature and the oxygen concentration, have a major influence on the dioxin formation and much more so than the content of chlorine.
- Whilst at the current levels of chlorine in municipal waste there does not seem to be a direct quantitative relationship between chlorine content and dioxin formation, it is possible that an increase of chlorine content in the waste stream above a certain threshold could contribute to an increase of the dioxin formation in incinerators. The threshold of 1% of chlorine has been suggested

	but uncertainties remain on the level of this threshold.

The Proposal for a Directive on the incineration of waste[(2)] foresees an emission limit value of 0,1 ng/m³. This shall decrease the emissions of dioxins from incinerators, esp. from those that at present are not yet operating with the state-of-the art technology.

(1)**COM(97) 358 final**

(2)**COM(1998) 558 final**

6.15 Information for footprint life cycle assessment of cartridges

Below the relevant DE Europe feedback is presented:

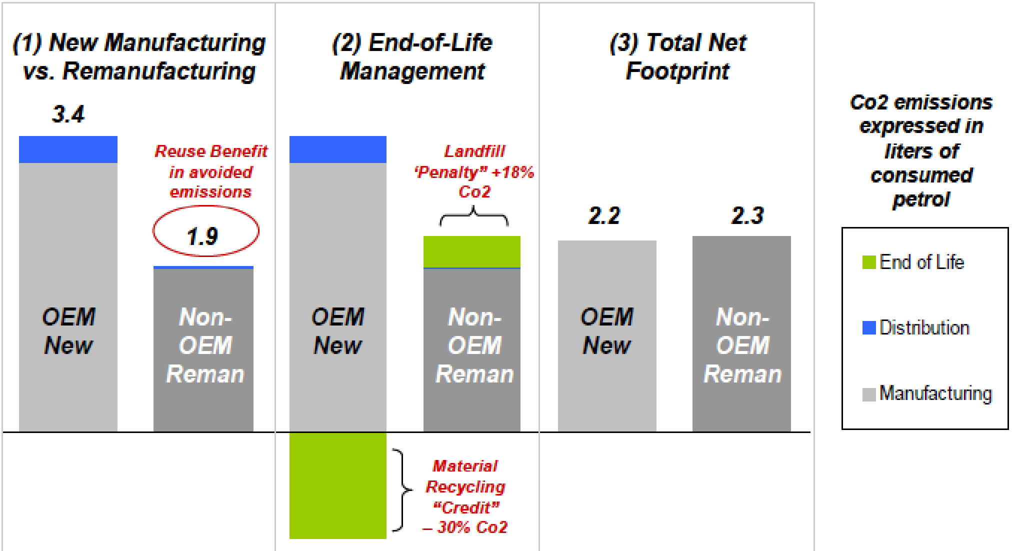
Industry data shows 80 % of aftermarket remanufactured toner cartridges are discarded after use due to non-OEM remanufacturers preference for virgin empties. [InfoTrends 2007 Supplies Recycling Report, pg 16].

Reuse and Remanufacturing can, under certain conditions offer the greatest carbon avoidance potential. In contrast to material recycling, however, the reuse of a toner cartridge does not end the product's life cycle. Quality and reliability during use of the remanufactured cartridge and its ultimate end-of-life management are crucial factors that shape the full life cycle footprint of the cartridge. Poor quality or irresponsible end-of-life handling can quickly offset the benefits of materials reuse. The following sections illustrate these factors using carbon footprint measurements of new and remanufactured cartridges.

To demonstrate the significant impact of proper end-of-life management, the chart below compares the carbon footprint of a new OEM cartridge (with material recycling after use) and a remanufactured cartridge without an end-of-life recycling program[89] (i.e. assuming the cartridge ends up in a landfill[90]):

[89] Examples based on a toner cartridge Life Cycle Assessment by WSP Environment and Energy for Lexmark, 7/2009, represents a T64X 21,000 page toner cartridge. Conducted in accordance with ISO 14044 guidelines for Life Cycle Assessment. Expressed in liters of petrol consumed from EPA Greenhouse Gas Equivalencies Calculator http://www.epa.gov/RDEE/energy-resources/calculator.html. Converted from gallons.

[90] "InfoTrends" research found that the chance of a remanufactured cartridge ending up in a landfill after the first remanufacturing cycle is high. In the U.S. and Europe, 80% of remanufactured toner cartridges and 86% of remanufactured inkjet cartridges are thrown away. This is because remanufacturers have such a strong preference for virgin empties" (InfoTrends 2007 Supplies Recycling Report, pg 16)



1. Here we see the initial benefit of remanufacturing vs. new manufacturing: Reuse of the cartridge materials through remanufacturing has a carbon footprint equivalent to burning 1.9 liters of petrol vs. 3.4 liters petrol equivalent for manufacturing a new cartridge.

2. Impact of End-of Life management: Assuming the empty new cartridge is collected and fully recycled (providing a 30% 'credit' to the footprint for returning those materials back to the materials stream), the remanufactured cartridge by weight (75 %) goes to landfill[91]. This gives the remanufactured cartridge an incremental +15 % footprint 'penalty'.

3. The net footprints of both the new cartridge (with material recycling at end-of-life) and the remanufactured cartridge (in landfill) are about equal, with the remanufactured version having a slightly larger environmental impact overall.

Without end-of-life material recycling, the reuse on an empty toner cartridge does not deliver an overall environmental benefit versus a new OEM cartridge material recycled at end-of-life.

Ultimately, the vendor of a remanufactured cartridge must collect and material recycle the product at its ultimate end-of-life in order to avoid offsetting the benefits of reuse. This is also the case for cartridges the vendor collects but does not reuse.

[91] Of the unusable cartridges collected by U.S. and European remanufacturers, we estimate that about 25% of the material is recycled." (2007 Supplies Recycling in US and Europe. InfoTrends. May, 2007. Page 10).

6.16 Additional Information for social criteria

The core ILO conventions are:

- Freedom of association
- Freedom of Association and Protection of the Right to Organize (No. 87)
- Right to Organize and Collective Bargaining (No. 98)
- Forced Labour
- Forced Labour (No. 29)
- Abolition of Forced Labour (No. 105)
- Equality
- Discrimination (Employment and Occupation) (No. 111)
- Equal Remuneration (No. 100)
- Elimination of child labour
- Minimum Age (No. 138)
- Worst Forms of Child Labour (No. 182)

The Electronic Industry Code of Conduct establishes standards to ensure that working conditions in the electronics industry supply chain are safe, that workers are treated with respect and dignity, and that business operations are environmentally responsible.

Considered as part of the electronics industry for purposes of this Code are Original Equipment Manufacturers (OEMs), Electronic Manufacturing Services (EMS) firms and Original Design Manufacturers (ODMs) including contracted labour that may design, market, manufacture and/or provide goods and services that are used to produce electronic goods. The Code may be voluntarily adopted by any business in the electronics sector and subsequently applied by that business to its supply chain and subcontractors.

To adopt the Code, a business shall declare its support for the Code and actively pursue conformance to the Code and its standards in accordance with a management system as set forth in the Code. The code shall be regarded as a total supply chain initiative. At a minimum, participants shall also require its next tier suppliers to acknowledge and implement the Code.

Fundamental to adopting the Code is the understanding that a business, in all of its activities, must operate in full compliance with the laws, rules and regulations of the countries in which it operates.