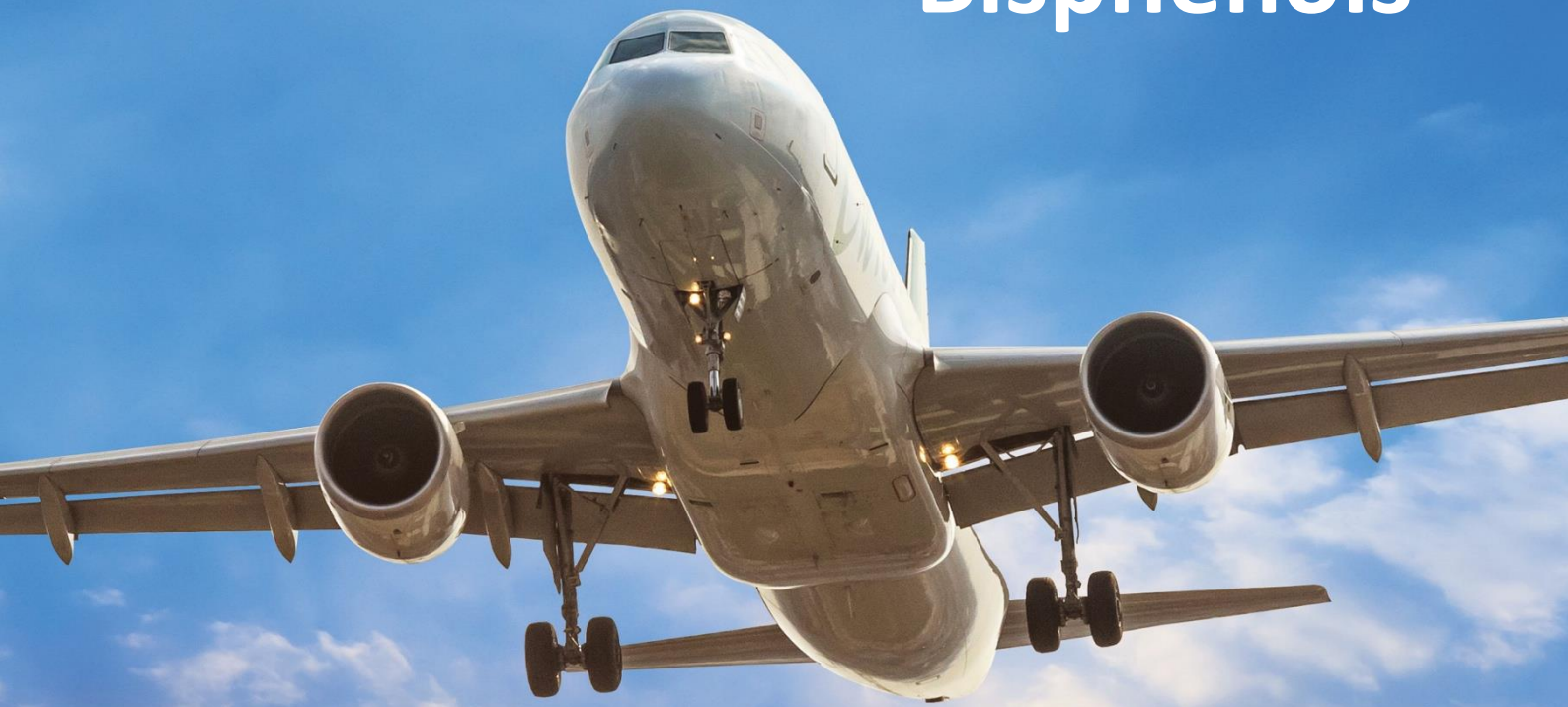
IAEG Review of Aerospace and Defence Dependencies relating to Bisphenols



IAEG Work Group 5

15 November 2024

IAEG Review of Aerospace and Defence Dependencies relating to Bisphenols

15 November 2024

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Contents

Glossary

Term	Definition
A&D	Aerospace and Defence
AIA	Aerospace Industries Association
ARN	Assessment of Regulatory Needs – includes substances for which an assessment either is under development or has been completed
ASD	Aerospace, security, and Defence Industries Association
Assembly	In the Aerospace and Defence industry, an assembly is several components or subassemblies of hardware which are fitted together to make an identifiable unit or article capable of disassembly such as equipment, a machine, or an Aerospace and Defence (A&D) product
BADCy	Bisphenol A dicyanate
BADGE	Bisphenol A diglycidyl ether
BoSC	Bisphenols of similar concern
BPA	Bisphenol A
BPAF	4,4'-[2,2,2-trifluoro-1-(trifluoromethyl)ethylidene] diphenol
BPB	4,4'-(1-methylpropylidene) bisphenol
BPF	4,4'-methylenediphenol
BPS	4,4'-sulphonyldiphenol
CAS	Chemical Abstracts Service – unique identifier for chemical substances
CLH	Harmonised Classification and Labelling – harmonised classification of certain substances helps guarantee protection to human health and the environment from the hazards the substance presents
CLP	Classification, Labelling, and Packaging
CMR	Carcinogenic, Mutagenic, or Reproductive Toxicity
Component	In the Aerospace and Defence industry, a component is any article regardless of size that is uniquely identified and qualified and is either included in a complex object (e.g. frames, brackets, fasteners and panels), or is a complex object itself (e.g. an assembly or sub-system)
DETDA	Diethyl-toluene-diamine
DGEBA	Diglycidyl ether of Bisphenol A
DtB	Design to Build
EASA	European Aviation Safety Agency
EC	European Community number
ECHA	European Chemicals Agency – source of information on the chemicals manufactured and imported in Europe
EEA	European Economic Area
EU	European Union
FAA	Federal Aviation Administration
FKM	Fluoroelastomers or fluoro rubber material
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
GIFAS	French Aerospace Industries Association
IAEG	International Aerospace Environmental Group
Intermediate substances	A chemical substance that is used to make other substances and are transformed into those other substances during the process
IPCS	International Programme on Chemical Safety
IUPAC	International Union of Pure and Applied Chemistry

Term	Definition
LER	Liquid Epoxy resin
Material	In the Aerospace and Defence industry, a material is the lowest level in the system hierarchy. Materials include items such as metals, chemicals, and formulations. In the context of this report, materials are bisphenols or formulations derived from bisphenols
MRO	Maintenance, repair, and overhaul
NLP	No longer polymer
NPRI	National Pollutant Release Inventory
OEM	Original Equipment Manufacturer
PACS	Priority Assessment Chemical Substances
PBT	Persistent, Bioaccumulative, and Toxic
PM	Preventative maintenance
PPE	Personal protection equipment
PPM	Parts per million
Product	In the Aerospace and Defence industry, a product is a finished assembly of components, such as an aircraft
PVC	Polyvinyl chloride
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals – a European Union regulation that governs the use and supply of chemicals
Regrettable substitution	When a harmful chemical is replaced with another chemical that is just as harmful or worse
RMOA	Risk Management Options Analysis
RPA	Risk & Policy Analysts Ltd.
SDS	Safety Data Sheets
SER	Solid Epoxy Resin
STOT SE	Specific Target Organ Toxicity Single Exposure
SVHC	Substances of Very High concern
TSCA	Toxic Substances Control Act
UVCB	Unknown or Variable Composition or Biological materials
vPvB	Very Persistent and Very Bioaccumulative
WG5	Working Group 5
WHO	World Health Organisation

1 Overview of this report

1.1 Introduction

In the EU, updates to REACH and the introduction of frameworks like the European Green Deal focus on reducing harmful substances and promoting a circular economy, aiming for sustainable chemical management. This has seen a rapid increase in evaluating the risks posed by chemical substances and regulators acting to limit use and exposure. These restrictions are expected to have impacts for the Aerospace and Defence (A&D) industry. This report seeks to add to the understanding of the impact bisphenol legislation in the EU would have on the A&D industry.

Bisphenol A (BPA) has been used industrially since 1946, and over time has found application in a wide variety of industries and products. Research has shown the substance to have estrogenic activity[1] with its mode of action being similar to the hormone oestrogen[2], classifying it as an endocrine disruptor. Although it is primarily used as an intermediate, it has been shown to leach out of consumer products such as polycarbonate plastics (used in e.g., baby bottles, food containers), polyvinyl chloride plastic films, and epoxy resin coated food cans[1]. This causes risks of exposure to humans and the environment that are not easily controlled. Due to these risks, countries are increasingly looking to control the use of BPA and structurally similar substances.

Previous restrictions[3] that solely targeted BPA did not consider structurally similar substances that may be used as alternatives to BPA. For example, Bisphenol S (BPS) was used as an alternative to BPA in thermal paper[4]. These structurally similar substances are likely to have equivalent hazardous properties to BPA. To avoid these "regrettable substitutions," emerging legislation[4] is likely to also include Bisphenols of Similar Concern (BoSC) into planned restriction proposals.

1.1.1 Purpose of this report

The International Aerospace Environmental Group (IAEG) commissioned this report to highlight the dependencies and critical uses of BPA and BPA derived products in the Aerospace and Defence (A&D) industry. The report also considers the challenges of further identifying BoSC in the supply chain. Additionally, supply chain complexities and substitution challenges are discussed. The purpose of the report is to inform the A&D industry of the work that has been undertaken by IAEG WG5 in partnership with Risk & Policy Analysts Ltd. (RPA).

The report is structured according to the following:

- **Section 2 Overview of Bisphenol A –** highlights the key uses of Bisphenol A in the A&D sector and the regulatory activities surrounding the substance.
- **Section 3 Overview of Bisphenols of Similar Concern –** provides an overview of bisphenols of similar concern and their uses.

[1] Vandenberg, L. N., Maffini, M. v, Sonnenschein, C., Rubin, B. S., & Soto, A. M. (2009). *Bisphenol-A and the Great Divide: A Review of Controversies in the Field of Endocrine Disruption*. https://doi.org/10.1210/er.2008-0021

[2] *Bisphenol A A Known Endocrine Disruptor A WWF European Toxics Programme Report*. (2000).

[3] Registry of restriction intentions until outcome – Restriction of BPA in thermal paper - found here https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18051ba62

[4] ECHA (2023), *Registry of restriction intentions until outcome. Information for Bisphenol A* found here https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e1853413ea

- **Section 4 Identified critical uses for Aerospace and Defence –** presents the critical uses of bisphenols and bisphenol derived products in the A&D sector.
- **Section 5 Residual Limits –** presents the complexities of understanding residual limits in bisphenol derived products.

1.1.2 IAEG

IAEG is a non-profit organisation comprised of over 65 member companies from the aerospace and defence industry. Delegates from each member company work to support different topics with working groups (WG). IAEG WG5 is the REACH Authorisation and Restriction work group, undertaking activities to assess and manage business continuity risks for the A&D industry arising from EU REACH regulatory activities.

2 Overview of Bisphenol A

2.1 Identification

The most common names and identifiers for BPA used within the industry, as well as the chemical structure of BPA, can be seen in Table 2-1 and Figure 2-1, respectively.

Table 2-1: Common identifiers of BPA	
Common names and synonyms	Bisphenol A BPA 2,2-bis(4-hydroxyphenyl)propane Phenol, 4,4'-(1-methylethylidene)bis- 4,4' – isopropylidenediphenol
IUPAC name	4-[2-(4-hydroxyphenyl) propan-2-yl]phenol
CAS #	80-05-7
EC #	201-245-8

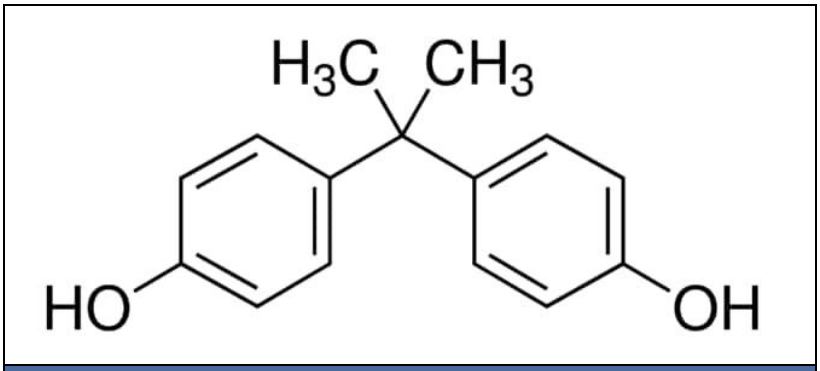


Figure 2-1: Molecular structure of BPA[5]

2.2 Properties of concern

The current harmonised classification and labelling in accordance with Regulation (EC) 1272/2008 (CLP Regulation), and in line with the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), as well as other registration information for BPA can be seen in Table 2-2.

Table 2-2: BPA hazard information[6]	
Property	**Description**
EU Harmonised Classification (see note 1)	Eye damage 1 (H318) Skin sensitiser 1 (H317) STOT SE 3 (H335) Aquatic acute 1 (H400) Aquatic chronic 1 (H410)

[5] https://www.sigmaaldrich.com/deepweb/content/dam/sigma-aldrich/structure9/054/mfcd00002366.eps/_jcr_content/renditions/mfcd00002366-large.png

[6] ECHA (2020) Summary of Classification and Labelling for BPA https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/54923

Table 2-2: BPA hazard information[6]	
Property	**Description**
	Reprotoxic 1B (H360F)
Specific concentration limit	M=1 M (chronic)=10
Tonnes per year (EU-REACH)	≥1 000 000
Candidate list (EU-REACH)	Yes
EU CLP signal word and pictograms	Danger 
Note 1: Under the Great Britain Mandatory Classification and Labelling (GB MCL), BPA has similar hazard classes omitting Aquatic acute 1 and Aquatic chronic 1. See the GB MCL here https://www.hse.gov.uk/chemical-classification/classification/harmonised-classification-self-classification.htm accessed June 2023	

According to Article 57 of the REACH Regulation[7], Substances of Very High Concern (SVHCs) are defined as those that are:

- Persistent, bioaccumulative, and/or toxic (PBT); or
- Carcinogenic, mutagenic, or toxic to reproduction (CMR); or
- Very persistent and very bioaccumulative (vPvB); or
- Have an equivalent level of concern.

Once identified as a SVHC, substances are added to the Candidate List for inclusion in Annex XIV (Authorisation List). The intention of including substances to Annex XIV is to ultimately substitute the use of the substance from the market. The identification of a substance as a SVHC triggers obligations by manufacturers, such as disclosing to the recipient of a mixture or article if the SVHC substance is present above a concentration of 0.1%.

BPA was identified as a SVHC in January 2017[9] due to its properties of concern including toxicity to reproduction and its endocrine disrupting properties to human health and the environment, presenting an equivalent level of concern.

2.3 Regulatory activity

2.3.1 History

In the EU and UK, BPA was included on the REACH Candidate List in January 2017 due to its properties of concern including toxicity to reproduction and endocrine disrupting properties to human health and the environment[9] presenting an equivalent level of concern. In the US, BPA is also subject to the toxic substances control act (TSCA) registered under the name Phenol, 4,4'-(1-methylethylidene) bis. Additionally, BPA is listed on relevant hazardous substance lists and chemical watch lists in other regions. For example, BPA is subject to California Proposition 65, and it is restricted in consumer articles by several US states. In Canada, it appears on the National Pollutant Release Inventory (NPRI) and is subject to pollution prevention planning notices. In Japan, under the Chemical Substances Control Law, BPA is on the Priority Assessment Chemical Substances (PACSs) list. In South Korea, BPA

[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006R1907-20221217

is a priority control substance, and it is classified as toxic in mixtures containing more than 0.3% of BPA. In India BPA is on the List of Priority Substances required to be registered.

Due to its hazard properties, BPA is also subject to additional EU and UK regulatory obligations under the CMR Directive to protect professional workers, consumers, and the environment; this includes occupational, safety and health legislation, environmental legislation, waste legislation, and consumer products legislation.

BPA has been the subject of regulatory action for many years due to its properties of concern. A summary of the main developments in the EU/UK are shown in Table 2-3.

Table 2-3: Regulatory activity for BPA

Date	Region	Regulatory activity
Dec 2016	EU	EU REACH Restriction of BPA in thermal paper[8]
Jan 2017	EU	Added to EU REACH Candidate List[9]
July 2017	EU	EU REACH Candidate list updated to add additional properties of concern[10]
Jan 2018	EU	EU REACH Candidate list updated to add additional properties of concern[11]
Sep 2018	EU	ECHA 9th draft recommendation for Authorisation[12]
Oct 2020	EU	EU CLP Regulation update to harmonised classification and labelling[13] [14] (see also Table 1-2)
Dec 2021	EU	ECHA published its Assessment of Regulatory Needs (ARN) for a group of 148 bisphenols and bisphenol derivatives[15]
Oct 2022	EU	EU REACH proposed restriction for BPA and BoSC

[8] Commission Regulation (EU) 2016/2235 of 12 December 2016 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the REACH as regards Bisphenol A – found here https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.337.01.0003.01.ENG&toc=OJ:L:2016:337:TOC

[9] ECHA (2017), Candidate List of substances of very high concern for Authorisation. Information for Bisphenol A found here https://echa.europa.eu/candidate-list-table/-/dislist/details/0b0236e180e22414

[10] See https://echa.europa.eu/documents/10162/eeed2c09-2263-25ad-49cd-a0926736c877

[11] See https://echa.europa.eu/documents/10162/ede153a4-db00-daf6-120f-6b6ccce0c539

[12] ECHA (2018), Recommendations for inclusion in the Authorisation List. Information for Bisphenol A found here https://echa.europa.eu/recommendations-for-inclusion-in-the-authorisation-list/-/dislist/details/0b0236e18289292f

[13] ECHA (2018), Registry of CLH intentions until outcome. Information for Bisphenol A found here https://echa.europa.eu/registry-of-clh-intentions-until-outcome/-/dislist/details/0b0236e18280184f

[14] According to the Registry of CLH intentions until outcome, https://echa.europa.eu/registry-of-clh-intentions-until-outcome/-/dislist/details/0b0236e18280184f, the additional hazard classes added for BPA included Aquatic Acute 1, H400 M-factor=1, Aquatic chronic 1, H410 M-factor=10.

[15] https://echa.europa.eu/documents/10162/3448017/GMT_109_Bisphenols_Report_public_23502_en.pdf/1bd5525c-432c-495d-9dab-d7806bf34312?t=1647590013566

Table 2-3: Regulatory activity for BPA		
Date	**Region**	**Regulatory activity**
Feb 2023	GB	UK REACH Risk Management Options Analysis (RMOA) consultation for BPA and BoSC[16]
August 2023	EU	Restriction proposal withdrawn

NOTE: REACH activities applied to both EU and GB until the UK left the EU on 31 January 2020 (Brexit transition), when UK REACH activity became independent of EU. It is not clear if the UK intends to restrict the use of BPA further or BoSC, there is currently no indication that the UK is planning to restrict bisphenols further.

2.3.2 Summary of EU Restriction Proposal (2022)

In October 2022, ECHA published the Annex XV restriction report for a proposal to restrict the use of 4,4'-isopropylidenediphenol (Bisphenol A) and Bisphenols of similar concern due to endocrine disrupting properties to the environment[17].

Although the restriction proposal was withdrawn in August 2023[18], the risk bisphenols pose remain, and it is expected a revised restriction proposal will be submitted sometime in the near future. It is expected that a revised restriction proposal will be similar to the original proposal and the risks to the A&D industry will remain.

To facilitate the understanding and motivation behind the development of this white paper, the scope and conditions of the previously withdrawn restriction proposal are presented in the following sections. For further notes and explanation, readers should refer to the withdrawn proposal directly[17].

2.3.2.1 Outline of the problem

The restriction proposal intended to address the risks to human health and the environment posed by BPA and BoSC. Specifically, the endocrine disrupting properties of BPA, BPB, BPS, BPF, and BPAF that fulfil the World Health Organisation (WHO)/International Programme on Chemical Safety (IPCS) criteria[19] for endocrine disrupting substances in the environment. There is currently no set safe threshold value for endocrine disrupting chemicals in the environment, and therefore, any environmental exposure can be taken as a proxy for risk. Due to the structural similarities of BPA and BoSC, to avoid regrettable substitution, it was deemed necessary to take EU-wide measures to reduce environmental emissions of these substances.

2.3.2.2 Proposed scope

The withdrawn restriction covered five bisphenols (BPA, BPB, BPS, BPF, BPAF), as well as covering any structurally similar bisphenols should they be identified as having endocrine disrupting properties in

[16] https://consultations.hse.gov.uk/crd-reach/bisphenol-rmoa-005/

[17] *Annex XV Restriction Report Proposal for a Restriction 4,4'-isopropylidenediphenol (Bisphenol A) and bisphenols of similar concern for the environment.* Submitted by the German Authorities. Found here https://echa.europa.eu/documents/10162/6b2321cf-5334-9354-cbcd-57a9345ae0fb

[18] Following the consultation, the dossier submitter concluded that a revision of the proposal was necessary. The revision expected to go beyond what can be dealt with within the boundaries of the current process and was therefore withdrawn.

[19] https://www.europarl.europa.eu/RegData/etudes/BRIE/2016/581986/EPRS_BRI(2016)581986_EN.pdf

the future. The grouping approach therefore covers all bisphenols fulfilling the criteria of having endocrine disrupting properties to the environment[20] and fitting the structural group boundaries described in the EU REACH restriction proposal[17].

There has been an incremental increase in regulatory activity affecting BPA over the last decade which has been largely manageable for the (A&D) sector. However, the withdrawn proposed EU restriction on BPA and BoSC represents a significant expansion, in scope and significance, from previous legislation in its potential to cause major disruption in the A&D supply chain.

Due to the endocrine disrupting properties of BPA and BoSC, the withdrawn EU REACH restriction proposal took a grouping approach covering all structurally similar bisphenols to reduce environmental exposure of endocrine disrupting bisphenols[17]. The withdrawn restriction allowed for the addition of further bisphenols if they were determined, in the future, to meet the restriction conditions.

Product obsolescence is a risk to the A&D industry due to long product use cycles and the level of risk must be understood for any future restrictions. Requirements to meet future restriction compliance would need to be known and such information (e.g., bisphenol presence and concentration) would need to be updated or provided and flowed down through the supply chain, alternative materials and processes developed, and then reincorporated into the system or article design. Implementing alternatives in the A&D industry is a complex and rigorous process that involves various stages and considerations. These processes are in place to ensure aerospace and defence products conform to strict safety and reliability requirements. Changes to materials and processes in the aerospace and defence industry must go through a rigorous framework that is more stringent than in many other industries[21], and is governed by regulatory bodies and agencies such as the EASA (European Aviation Safety Agency) and the FAA (United States Federal Aviation Administration). This can be an extremely involved and time-consuming task for the A&D industry. Therefore, future restrictions could have a significant impact on the industry.

2.4 Use of Bisphenol A

The global BPA market was estimated to be around 6.2 million metric tonnes in 2020 and increasing[22]. Although BPA is primarily used in polymers, as a basic building block for other chemical substances (as a chemical intermediate), and as an additive. A significant volume of BPA is used to produce polycarbonate plastics globally. It is estimated that polycarbonates make up at least two-thirds of BPA consumption[23]. Similarly noted in sources in the withdrawn EU REACH Annex XV Restriction Report[17], it was estimated that within the European region in 2019 and 2020, around 80% (1,155,000 tonnes) of processed BPA was used to produce polycarbonates, around 19% (275,000 tonnes) was used to produce epoxy resins, and 0.9-1.4% (13,000-20,389 tonnes) was used in other applications. The global

[20] The Restriction Proposal states, "*that every emission of endocrine disrupting bisphenols to the environment increases the likelihood of irreversible and adverse effects relevant to the population level, i.e. effects on reproduction, growth and survival*."

[21] Aerospace and Defence Qualification Process Impacts on Ability to Substitute Cr(VI) substances http://www.stylususa.com/-/media/files/reh/GCCAAerospaceDefenceQualificationProcessImpactsonAbilitytoSubstituteCrVISubstances whitepaper accessed May 2023

[22] L. Trullemans, et al. *Polym.Chem.,* 2021, 12, 5870

[23] https://www.spglobal.com/commodityinsights/en/ci/products/bisphenol-chemical-economics-handbook.html accessed June 2023

BPA market additionally comprises epoxy resins, unsaturated polyester resins, flame retardants, and other applications[24].

A summary of annual EU BPA-based polymer tonnages is shown in Table 2-4. Please note, this information was taken from Annex H in the EU REACH Restriction report[25] and the table is non-exhaustive. There were some significant data gaps in terms of tonnage, this is seen in the table indicated as 'n.a.' or not available. Whilst A&D are not highlighted as significant consumers in any categories, such uses could be expected to comprise a smaller proportion of other categories e.g. electronics, and coatings.

Table 2-4: Tonnages of BPA-based additives and BPA polymers in Europe (2020)[25]

Use	Annual tonnage of BPA			
	Processing	Import	Export	Consumption
BPA-based additives				
Hardener in epoxy resins	n.a.	n.a.	n.a.	n.a.
BPA polymers				
Polymerisation of polycarbonates	1,155,000	100,000	-300,000	955,000
Polymerisation of epoxy resins	275,000	75,000	-100,000	250,000
Polymerisation of polyarylates	n.a.	n.a.	n.a.	n.a.
Polymerisation of polyetherimides	1,740	n.a.	n.a.	1740
Polymerisation of benzoxazines	n.a.	n.a.	n.a.	n.a.
Polymerisation of phenolic resins	8,800	n.a.	n.a.	8800
Polymerisation of polycyanurates	n.a.	n.a.	n.a.	n.a.
Polymerisation of vinyl ester resins	n.a.	n.a.	n.a.	n.a.
n.a. = not available				

Within the EU REACH Restriction report there is also a breakdown of use sectors and applications. Whilst A&D does not appear to be a dominant sector for known uses of BPA, it is likely there will be relevant A&D applications in common with uses identified in many of the included sectors (e.g., building and construction, electrical, automotive, and safety and leisure).

BPA is widely used due to its contribution to enhancing key properties for an extensive range of products that are derived from the substance. For example, BPA is used in polymers to create rigid and impact resistant plastics. It is used to produce strong and durable polycarbonate[26]. Alternatively, it can be used for clarity and transparency of plastics for products such as eyeglasses[26]. In addition to strength and durability, BPA can improve the chemical and thermal resistance of polymer products. The use of BPA to produce epoxy resins allows them to be used in high-performance environments where chemical and thermal resistance are required.

[24] https://www.mordorintelligence.com/industry-reports/bisphenol-a-bpa-market accessed June 2023
[25] *Annex XV Restriction Report Proposal for a Restriction 4,4'-isopropylidenediphenol (Bisphenol A) and bisphenols of similar concern for the environment* – Annex H https://echa.europa.eu/documents/10162/9256e73b-0aa1-68ee-5afd-61391613b91c
[26] https://www.factsaboutbpa.org/benefits-applications/ accessed May 2023

The Royal Society of Chemistry based in the UK reported in 2012[27] the main global uses of BPA were:

- Production of polycarbonate (around 66% of total use);
- Production of epoxy resins (around 30% of total use);
- Production of other resins (around 2% of total use) including phenolic resins and polyester resins; and
- Production of tetrabromobisphenol-A flame retardants (around 2% of total use).

Other minor uses were stated to be the following:

- PVC production and processing;
- Ethoxylated bisphenol-A manufacture;
- Thermal paper manufacture (Restricted in 2016[28]);
- Manufacture of polyols/polyurethane;
- Manufacture of modified polyamides;
- Tyre manufacture; and
- Brake fluids.

Whilst uses of BPA derived products in the A&D sector are expected to make up a smaller proportion of the overall BPA use, the small proportion used is critical for the manufacture, maintenance, and repair of aerospace and defence products.

[27] https://www.rsc.org/images/Scientific%20Note%20Why%20do%20we%20worry%20about%20Bisphenol-A_tcm18-227250.pdf accessed 7 February 2023

[28] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.337.01.0003.01.ENG&toc=OJ:L:2016:337:TOC

3 Overview of Bisphenols of Similar Concern

3.1 Identification

BPA is normally synthesised from the condensation of phenol and acetone[29]. The generic structure of bisphenols is given in Figure 3-1, note the two phenol groups. Additional bisphenols are produced by altering the atoms or groups denoted by "X" or "R".

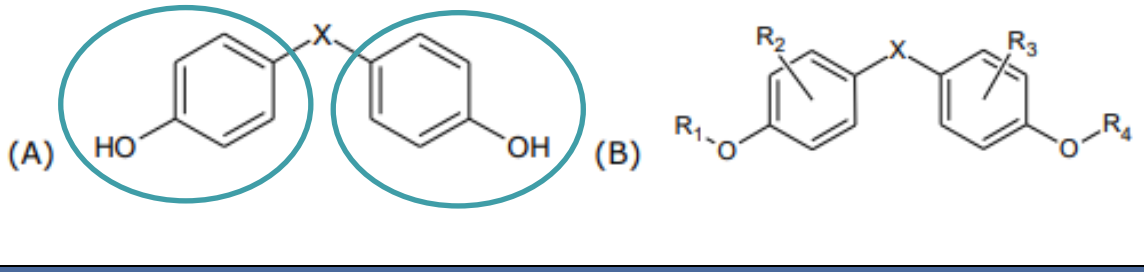


Figure 3-1: General structure of bisphenols[30]
(A) Generic bisphenol, with Phenol indicated in the oval
(B) X and R indicate substitution sites to create additional bisphenols, i.e.: the difference between one bisphenol and another are differences in the atoms or groups at these sites

Due to their structural similarity, many bisphenols could likely provide the same functionality in some applications. However, these similar structures could also give rise to similar hazardous properties. Figure 3-2 shows how the structures are related to potentially harmful biological activity.

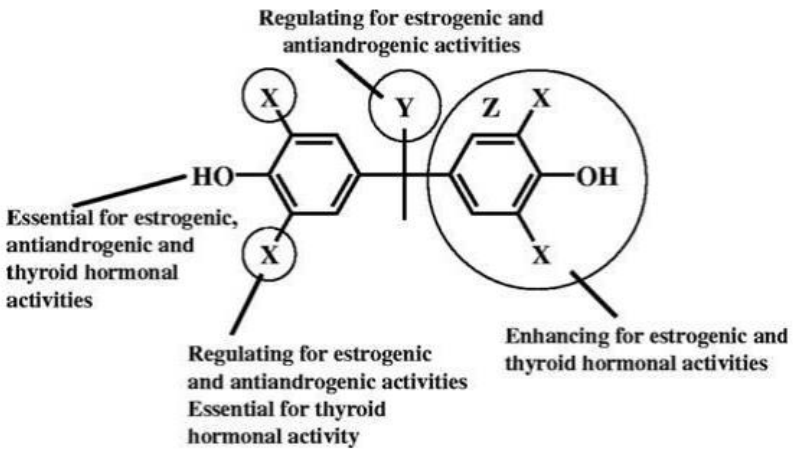


Figure 3-2: Structural elements of phenols important to exert different hormonal activities[31]

[29] Allcock, Harry, et al. Contemporary Polymer Chemistry, 3rd Edition, Pearson Education, 2003 (p36)

[30] https://echa.europa.eu/documents/10162/3448017/GMT_109_Bisphenols_Report_public_23502_en.pdf

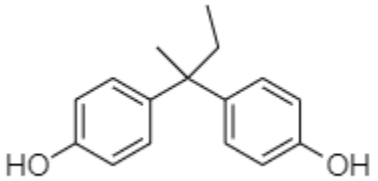
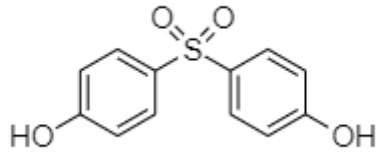
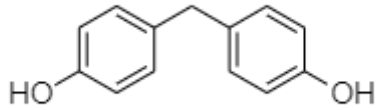
[31] *Kitamura S., Suzuki T., Sanoh S., Kohta R., Jinno N., Sugihara K., Yoshihara S., Fujimoto N., Watanabe H., and Ohta S. (2005): Comparative study of the endocrine-disrupting activity of bisphenol A and 19 related compounds. Toxicol Sci 84 (2), 249-259. DOI: 10.1093/toxsci/kfi074*

BoSC is the name given to the group of the structural analogues similar to that of BPA listed in the proposed EU REACH restriction proposal (e.g., BPB, BPS, BPF and BPAF). These BoSC all meet the WHO/IPCS criteria for endocrine disrupting substances in the environment[32]. In addition, in an EU ARN carried out in December 2021, ECHA and Member States reviewed 148 bisphenols and recommended that 34 of these bisphenols should have restriction as a follow-up action[33] due to their potential endocrine disrupting properties. Bisphenols not in a restriction proposal are not subject to further regulatory action. However, these substances may be determined to have properties of similar concern in the future, therefore their use as alternatives to BPA and BoSC should be carefully assessed to prevent possible regrettable substitutions.

The bisphenols designated as BoSC within scope of the withdrawn restriction are presented in Table 3-1.

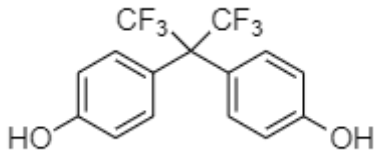
[32] Found at: Global assessment on the state of the science of endocrine disruptors (who.int) accessed January 2023

[33] Bisphenols Assessment of Regulatory Needs, found at: https://echa.europa.eu/documents/10162/3448017/GMT_109_Bisphenols_Report_public_23502_en.pdf

Table 3-1: Identity and registration status of Bisphenols of Similar Concern within the withdrawn EU REACH Restriction proposal					
Name	**EC number**	**CAS number**	**Tonnage registered (t/y)**	**No. active EU registrants**	**Structure**
4,4'-(1-methylpropylidene) bisphenol (Bisphenol B)	201-025-1	77-40-7	BPB is not registered under REACH; however, it has been found in biological samples from European populations and in environmental media in China. Most likely it is used outside the European Economic Area (EEA) as a direct substitute for BPA in the manufacture of polymers. There is also a possibility that it could be used within the EEA but in quantities below the registration threshold. The ECHA dissemination site[34] suggests a tonnage band of 1 – 10 tonnes per annum.	N/A	
4,4'-sulphonyldiphenol (Bisphenol S)	201-250-5	80-09-1	BPS is registered under the REACH Regulation and is manufactured in and / or imported to the EEA, at ≥ 10 000 tonnes per annum.	12	
4,4'-methylenediphenol (Bisphenol F)	210-658-2	620-92-8	BPF is not registered under the REACH Regulation. BPF is likely imported within a polymer, though it does not meet the criteria for a polymer, so the monomers would require registration[35]. It would be part of a UVCB. However, BPF and its regioisomers (CAS-no. 1333-16-0) are manufactured in and / or imported to the EEA, at ≥ 1 000 to < 10 000 tonnes per annum.	N/A	

[34] https://echa.europa.eu/de/substance-information/-/substanceinfo/100.000.933

[35] ECHA Guidance for monomers and polymers (2023), available here: https://echa.europa.eu/documents/10162/2324906/polymers_en.pdf/9a74545f-05be-4e10-8555-4d7cf051bbed?t=1676975081896

Table 3-1: Identity and registration status of Bisphenols of Similar Concern within the withdrawn EU REACH Restriction proposal					
Name	**EC number**	**CAS number**	**Tonnage registered (t/y)**	**No. active EU registrants**	**Structure**
4,4'-[2,2,2-trifluoro-1-(trifluoromethyl)ethylidene] diphenol (Bisphenol AF)	216-036-7	1478-61-1	BPAF is registered under the REACH Regulation and is manufactured in and / or imported to the EEA, at ≥ 100 to < 1 000 tonnes per annum.	18	
Source: ECHA dissemination portal					

3.2 Generic uses of Bisphenols of Similar Concern

Due to the structural similarities of BoSC to BPA, they could be expected to have similar uses to that of BPA. For this reason, EU REACH proposes to restrict similar bisphenols in the same way as BPA, to avoid regrettable substitution. A general overview of BoSC uses is highlighted in the sections below.

3.2.1 Bisphenol B (BPB)

BPB's chemical structure is very similar to BPA apart from the addition of one methylene unit between the two phenol moieties. Therefore, there is a risk that the uses could be very similar to BPA[25] for example use in the manufacture of phenolic and polycarbonate resins[36] and is already used as an alternative to BPA in some uses[37]. Currently the use of BPB in A&D is unknown and further investigation into the A&D supply chain is required to make an informed assessment.

3.2.2 Bisphenol S and its derivatives

The derivatives of BPS have in common, the same bridge between the two phenyl rings, but with different substituents. In the EU REACH restriction report from October 2022, this group includes 11 substances with structural similarities meaning they could have a similar use profile as BPS. Known uses of BPS include leather treatment products, paper chemicals, and polymers[25]. Another important use of BPS is in thermal paper[25]. Additionally, it is used in syntan[38] and textile auxiliary polymers[25].

3.2.3 Bisphenol F and its derivatives

The derivatives of BPF are structurally similar substances that include the same bridge as BPF between the two phenyl rings. In the EU REACH restriction report from October 2022, this group includes 17 substances. BPF is commonly used in epoxy resins, which could be used within the A&D industry, but its use would need to be investigated further[25]. According to the restriction proposal, BPF can be found in products with material based on: leather (e.g. gloves, shoes, purses, furniture), paper (e.g. tissues, feminine hygiene products, nappies, books, magazines, wallpaper), paper used for articles with intense direct dermal (skin) contact during normal use such as printed articles (e.g. newspapers, books, magazines, printed photographs) and paper used for articles with intense direct dermal (skin) contact during normal use such as personal hygiene articles (e.g. nappies, tissues, towels, toilet paper)[25]. Additionally, it may be used in syntan and textile auxiliary polymers.

Its derivatives will be present in coatings, polymers/plastic, board and paper, manufacture of other chemicals, finger paint and fillers, adhesives, lubricants and greases, washing and cleaning agents, perfumes and fragrances, plant protection products, photochemicals as well as leather and textile[25].

BPF derivatives can be used as a complementary building block in epoxy resins where they are used as intermediates.

[36] https://pubchem.ncbi.nlm.nih.gov/compound/Bisphenol-B#section=Use-and-Manufacturing accessed August 2023

[37] https://www.anses.fr/en/content/bisphenol-b-endocrine-disruptor-humans-and-environment accessed August 2023

[38] Any of a class of synthetic tanning materials that are sulfonated condensation products of aromatic compounds with formaldehyde or some other aldehyde.

3.2.4 Bisphenol AF and its salts

BPAF[39] and its derivatives are used as monomers in plastics and polycarbonates[25]. It is also used as a reactive process regulator in polymer materials and is further used as a crosslinking agent for certain fluoroelastomers (FKM)[25].

[39] It should be noted that BPAF is also subject to the current PFAS restriction. Based on the definition given in the current restriction proposal, BPAF is classed as a PFAS. See the current PFAS restriction proposal here https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

4 Identified critical uses for Aerospace and Defence

4.1 Introduction

Products, components, or assemblies used in the A&D industry must meet stringent original equipment manufacturer (OEM) specifications and third party, for example EASA, and FAA regulatory standards. Specific requirements are associated to the functionalities a particular material needs to demonstrate, and this can vary for use on different types of components, in different assemblies, and different locations within a single product.

In the example of an aircraft, a component or assembly using materials in the hot section of an engine will have different requirements than a component or assembly used in the cabin. Nevertheless, these components and assemblies must be long-lasting and perform, in some cases, in extreme environments. Within the aerospace and defence industry, products and assemblies undergo regular preventative maintenance (PM) and maintenance, repair, and overhaul (MRO) intervals. These activities occur at intervals that are pre-determined on the observed performance life of the components within a particular assembly. During MRO activities, if the components are observed to be in a better condition than anticipated then the MRO schedule[40] will be adjusted based on this real-life experience.

4.2 Aerospace and Defence uses

The aerospace and defence industry relies heavily on polycarbonates and epoxy resins as materials used in key structural components and assemblies. The manufacture of polycarbonates and epoxy resins is known to be a major use of BPA. It can be difficult to understand if future restrictions can be complied with due to lack of visibility of all BPA uses throughout the supply chain.

Bisphenol A Diglycidyl Ether, more commonly known as BADGE, is derived from BPA and is registered under REACH (see Table 4-1). Almost 75% of epoxy resins currently used worldwide are derived from BADGE. BADGE is also known as diglycidyl ether of bisphenol A (DGEBA)[41] [42] or liquid epoxy resin (LER). BADGE is synthesised from the reaction of BPA with 1-chloroprene 2 oxide (epichlorohydrin), in the presence of sodium hydroxide.

Determining substance identities can be confusing because when DGEBA and/or BADGE and/or LER was registered in Europe and the USA, different chemical names and CAS numbers were used:

1. In Europe and the USA, bisphenol A diglycidyl ether (CAS 1675-54-3 and EC 216-823-5), was used to describe the purified resin.

2. In the USA, ‘bisphenol A diglycidyl ether – epoxy resin (CAS 25085-99-8)’ describes the technical grade. This will continue to be used in the USA because the majority of substance entries, the industry formulations, and Safety Data Sheets (SDSs) contain this chemical substance name and CAS number.

[40] The MRO schedule is set by the design owner. Companies engaged in MRO activities face particular substitution difficulties as they may be mandated to continue using specific materials if it is specified in the Maintenance Manuals provided to them by the OEMs.

[41] Choi, K. E. (2013). A Study on the Preparation of the Eco-friendly Carbon Fibers-Reinforced Composites. Carbon letters, 14(1), pp.58-61.

[42] Petrie, E. (2005). Epoxy Adhesive Formulations. New York: McGraw-Hill Chemical Engineering.

3. In Europe, 'Bisphenol A epichlorohydrin polymer (CAS 25068-38-6)' describes the technical grade. The technical grade substance was first defined in Europe as a polymer and was exempt from registration. This substance was later described as a No-Longer Polymer (NLP) and registered under EC number 500-033-5. After registering the NLP substance under the REACH regulation, the authorities recommended, as the substance was pure enough, describing the technical grade substance as bisphenol A diglycidyl ether (CAS 1675-54-3 & EC 216-823-5). This REACH registration now covers the (original) technical grade DGEBA and/or BADGE, and the purified grade. The old CAS number 25068-38-6 is still commonly used in company formulations and SDSs.

Table 4-1: BADGE EU registered information[43]

Property	Description
EC number	216-823-5
CAS number	1675-54-3
Official CLH hazard classes and codes	Skin irritant 2 (H315) Eye irritant 2 (H319) Skin sensitiser 1 (H317)
Specific conc. limit	Eye irritant 2; H319: C ≥ 5% Skin irritant 2; H315: C ≥ 5%
Tonnes per year (REACH)	≥ 100 000 to < 1 000 000
Candidate list (REACH)	No

BADGE is a chemical substance (not a polymer) that is registered in many countries. LER or BADGE has a low molecular weight (n[44]= 0 to 0.2) and is often used for the ease of mixing with hardeners or curing agent[45]. The addition of curing agents and hardeners to BADGE-based formulations plays an important role in determining properties of the cured matrices such as cohesive strength, hardness, toughness, flexibility, chemical resistance, and heat resistance[46]. A wide variety of properties can be attained through these curing techniques, including those essential for extreme applications.

For example, BADGE, when cured with the aromatic amine diethyl-toluene-diamine (DETDA), produces a matrix with a high glass transition temperature suitable for high temperature composite applications, whereas BADGE cured with polyetheramines forms a flexible network suitable for vibration dampening applications.

[43] *ECHA (2020) Summary of Classification and Labelling for BADGE* https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/97651 accessed June 2023

[44] The properties of BADGE epoxy resin, in this case molecular weight, are dependent on the degree of polymerisation (n), and purity.

[45] Environment and Climate Change Canada Health Canada (2014). Draft screening assessment Epoxy Resins Group: https://www.canada.ca/content/dam/eccc/documents/pdf/pded/epoxy-resins/20180321-dsar-epoxy-resins-en.pdf.

[46] Durig, J. J. (1999). Comparisons of epoxy technology for protective coatings and linings in wastewater facilities. The Industrial Protective Coatings Conference and exhibit: Proceedings of the seminars (pp. 31-37). Houston: Technology Publishing company.

BADGE and BADGE epoxy resins in the A&D industry

Consultation activity with IAEG WG5 members was undertaken to gather information on uses of BADGE products/formulations in the A&D industry. Out of the 6,000 'material uses[47]' identified, 90% used at least one of the following four BADGE substances:

1. Bisphenol A diglycidyl Ether (CAS 1675-54-3 and EC 216-823-5);
2. Bisphenol A diglycidyl Ether - Epoxy resin (CAS 25085-99-8 and EC 216-823-5);
3. Bisphenol A diglycidyl ether - bisphenol A copolymer (CAS 25036-25-3 Polymer); and
4. Bisphenol A epichlorohydrin polymer (CAS 25068-38-6 and EC 500-033-5/216-823-5 and Polymer).

A summary of the properties and uses of each of the four BADGE substances identified during the consultation as having 'material uses' in A&D are given in Table 4-2.

Table 4-2: BADGE uses in A&D sector

BADGE substances	Application
Bisphenol A diglycidyl ether (CAS 1675-54-3 EC 216-823-5)	Bisphenol A diglycidyl ether has high purity with a low oligomer content and a low viscosity. A wide variety of cure agents are compatible with this BADGE and under elevated temperatures chemical resistance and glass transition temperatures are increased. This resin grade is mainly used in: • filament winding; • electrical laminates and encapsulation applications; • adhesives; • casting; • composites; • photocured industrial coatings; and • potting.
Bisphenol A diglycidyl ether – epoxy resin (CAS 25085-99-8)	Liquid BADGE epoxy resins are the most widely used general purpose epoxy resins, often used as a standard from which many variations have been developed. This is due to the wide variety of compatible curing agents, high viscosity (for degree of polymerisation n = 0.2), and quick time to gel. Because liquid BADGE epoxy resin is so widely used, there are a number of applications, including: • adhesives; • casting and tooling; • composites; • automotive coatings; • can and coil coatings; • potting and encapsulation; • marine and protective coatings; and • photocured industrial coatings and civil engineering.

[47] Products that contained BPA or BPA derived substance.

Table 4-2: BADGE uses in A&D sector	
BADGE substances	**Application**
Bisphenol A diglycidyl ether - bisphenol A copolymer (CAS 25036-25-3)	This copolymer is solid at room temperature (n > 1) which makes the curing process more difficult. It is used to make resins with good physical strength, toughness, adhesion, chemical resistance, and low shrinkage properties. This copolymer is commonly used in: • composite and casting applications; • tooling; • encapsulation; • adhesives; and • filament winding and laminates. It should be noted that this substance name and CAS number are also used to describe a curing agent/hardener. When it is produced using a stoichiometric excess of BPA, the polymer exhibits phenolic functionality. The typical properties should be reviewed, and a Hydroxyl Equivalent Weight (g/eq) confirms the phenolic functionality.
Bisphenol A epichlorohydrin polymer (CAS 25068-38-6)	Bisphenol A epichlorohydrin polymers were the most common BADGE substances identified by IAEG members. This substance can have a very low degree of polymerisation (n≈0.2) and be a high viscosity liquid (LER or BADGE). This polymer is often used as a starting material to produce higher molecular weight, solid epoxy resins. These solid epoxy resins are often described using CAS numbers 25068-38-6 and 25036-25-3.

In summary, the important epoxy resins for the A&D industry are:

1. LER, BADGE, or DGEBA, is produced by the reaction of epichlorohydrin and BPA. For this substance, BPA is an intermediate. BADGE is a REACH registered chemical substance (CAS 1675-54-3 and EC 216-823-5); not currently being considered as a SVHC[48].

2. Solid epoxy resins (SER) and/or high molecular weight epoxy resins produced by the reaction of BADGE/DGEBA/LER and BPA. These are polymers, where BPA is a monomer. Under REACH, monomer uses of BPA are by definition intermediates.

EU Public consultation activities associated with BPA's candidate list entry, and ECHA's 9th draft recommendation, highlighted the specific importance of the substance to the aerospace and defence industry[49]. Extensive comments were submitted by the Aerospace and Defence Industries Association of Europe (ASD), the Aerospace Industries Association (AIA) and the French Aerospace Industries Association (GIFAS). These comments are in line with the BPA-derived product uses later identified during WG5 activities (see Table 4-2), such as:

- Intermediate use to manufacture epoxy resin e.g., BADGE[50] (bisphenol A diglycidyl ether):
  - Epoxy resins for composite materials for structural components for weight and CO_2 emission saving;

[48] An endocrine disruptor assessment was done in 2021 was determined to be inconclusive based on the data available. It was concluded that there is currently no need for regulatory follow-up action at the EU level, but a residual concern for endocrine disruption. This could likely undergo another assessment in the future.

[49] ECHA. (2018). *BPA: Comments submitted to ECHA's draft 9th recommendation.* Retrieved from https://echa.europa.eu/documents/10162/c9f7bb4d-7c1f-1583-bab5-b74c0867217f

[50] BPA and epichlorohydrin are reacted to create BADGE. BADGE and BPA can be reacted further (monomers) to create solid epoxy resins.

  - Epoxy resins as potting compounds for the majority of electrical components used on printed circuit boards;
  - Epoxy adhesives for modern manufacturing techniques; and
  - Epoxy paints and varnishes for long-lived products.

- Intermediate use to manufacture polycarbonate. Parts produced out of polycarbonate include but are not limited to:
  - Windows for aeroplanes;
  - Covers for position lights etc;
  - Personal protection equipment for civil and military usage (goggles, visors of helmets);
  - Seating;
  - Electrical insulation; and
  - Optical components for modern communication devices.

Critically, the above-mentioned uses of BPA in epoxy resins and polycarbonates have been identified as intermediates. Such intermediate uses would be exempt from any future REACH authorisation requirement in accordance with Article 2(8)(b)[51] of REACH but would still be subject to restriction activities.

A separate non-intermediate use of BPA exists within hardener formulations used to cure epoxy resins. Curing is a process whereby a polymer material is toughened or hardened by the cross-linking of polymer chains. Epoxy resins are mostly cured with BPA-free hardeners. Common curing compounds of BADGE include polyamines (ethylene diamine, diethylene triamine, triethylene tetraamine), polyamides, cyclic acid anhydrides, polymercaptans, isocyanates, amino resins, and phenolic resins.

A high-level summary of BPA uses identified in the withdrawn Restriction report that are used within the A&D sector can be seen in Table 4-3.

Table 4-3: BPA uses in A&D sector[25]

Use	Application
BADGE (liquid epoxy resin) and epoxy resin feedstock for solid epoxy resins	• Lightweight composite components in primary and secondary structures – contributes to fuel consumption and emission savings • Adhesives, paints and varnishes, potting for electrical components, hardeners
Polycarbonates	• Interior applications such as, bulkheads, bins, compartments, dashboard components, windows, electrical insulation, position light covers, personal protection equipment (PPE) equipment
Bisphenol A dicyanate (BADCy)	• Filament windings, fibre-reinforced composites, pultrusion and syntactic foams
Vinyl ester resins	• Coatings and adhesives, moulding components, structural laminates

[51] According to the *Guidance for monomers and polymers* found on the ECHA website, "any substance used as a monomer in the manufacturing of a polymer is therefore by definition an intermediate. Nonetheless, the specific provisions for the registration of intermediates under REACH do not apply to monomers." Guidance found here https://echa.europa.eu/documents/10162/2324906/polymers_en.pdf/9a74545f-05be-4e10-8555-4d7cf051bbed?t=1676975081896

Table 4-3: BPA uses in A&D sector[25]	
Use	**Application**
Polycyanurates	• Fibre enforced composites – typically used in the cabin of an aircraft
Polyetherimide	• Electromagnetic interference shielding, aircraft interiors
Polyarylates	• Self-lubricating bearings, o-rings, reinforcing fibres for ropes, cables, and composites
Polybenzooxazine resin	• Fibre reinforced plastics, adhesives
Phenolic resins	• Fibre reinforced composites for lining aircraft cabins

4.3 Supply chain visibility

An aircraft or defence system is comprised of many components and assemblies with design and manufacture occurring globally. Companies within the A&D industry supply chain can be importers, formulators, distributors, downstream users (OEMs), design to build (DtB)) or MRO providers (civilian and military)[52]. Typically, it is OEMs[53] or DtB[54] that act as design owners and establish the detailed performance criteria that must be met by individual components, assemblies, and final products, in order to ensure that airworthiness and military standards are met. To this end, formulators and component manufacturers must meet the performance specifications mandated by the OEMs. This results in materials and processes being selected that are proven to meet the desired performance specifications; OEMs do not always have visibility of the full composition, only those substances subject to communication requirements (e.g., those materials that must be disclosed for regulatory purposes).

Aerospace and Defence companies use high performance products and formulations. Once a technical solution has been found that meets the required performance specifications in an A&D product, any deviation from that technical solution (i.e., development and implementation of an alternative) requires extensive testing, and approval often requiring long transition periods. This is to ensure that product safety and mission critical objectives are not affected.

The nature of supply chain relationships and interlinkages is complex and can exist between suppliers in different geographic regions. The complexity of these interlinkages within the aerospace supply chain is highlighted below in Figure 4-1.

[52] It is important to note that companies may fit into more than one of the above categories, acting as an OEM, DtB, and MRO, where they service components, they designed and manufactured which are already in use. Similarly, a company may fall into different categories depending on the customer and the component/final product.

[53] Original equipment manufacturers design, assemble and sell engines, aircrafts, space, and defence equipment to the final customer.

[54] Design to build companies will design and build specific components.

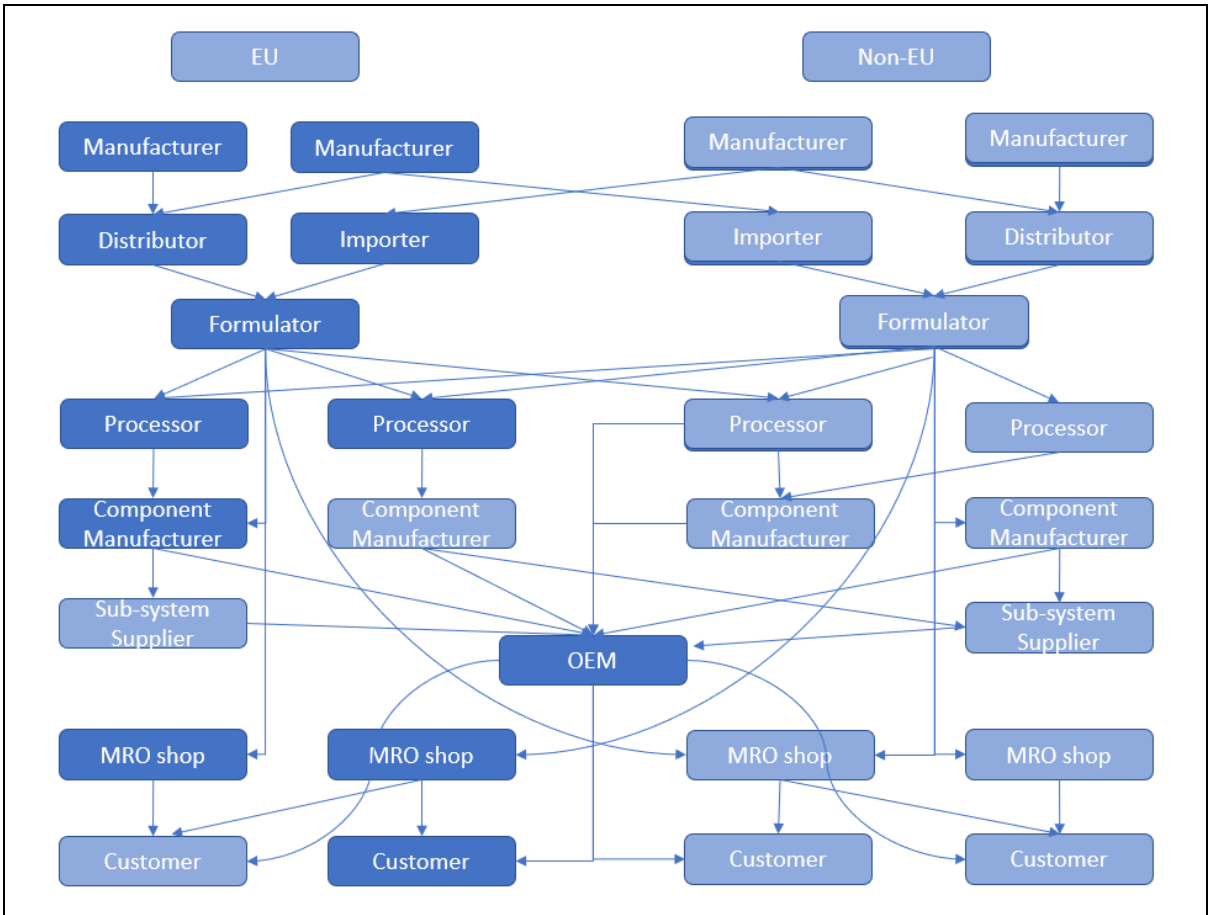


Figure 4-1: Complexity of supply chain roles and relationships with the A&D sector[55]

As an example of the complexity of the A&D supply chain, the upstream suppliers and sub-contractors of a 787 Dreamliner are shown in .

Analysis of each of these system suppliers identifies an extensive network of suppliers and contributors, including a number of small and medium sized enterprises. Although not all of these components and systems are associated or derived from the use of BPA, the fact that a range of suppliers from around the globe are involved still holds.

[55] *Socio-economic analysis for the use of strontium chromate in primers applied by A&D companies and their associated supply chains submitted by Wesco Aircraft EMEA Limited.* Full report found here https://echa.europa.eu/documents/10162/509fcbfb-496c-a3de-d4f8-f4b88ef9c5c0

Figure 4-2: Global contributors of selected components and systems suppliers of 787 Dreamliner aircraft parts[56]

The complexity of the supply chain often makes it difficult for aerospace and defence manufacturers, OEMs, or MRO companies to identify where substances are used within final assemblies or products.

Communication requirements are not uniform for formulators or manufacturers located across different regions with differing regulatory requirements and are often not comprehensive enough for complete transparency downstream. For example, in the EU and UK, SVHCs[57] are required to be reported in SDSs (for mixtures), and via other appropriate means for articles (Article 33), above a concentration of 0.1%. This allows industrial and professional users to make informed decisions when sourcing articles. However, SVHC presence below 0.1% is not required to be reported and thus could still be present in the article. These requirements are only for substances, or substances in articles, which are physically delivered to OEMs and not those that are used in the process, this would need to be requested and agreed upon between supply chain actors. Identifying substances used within A&D that do not fall into any scope for communication is an extremely difficult and laborious task and often requires one-to-one engagement with each actor in the supply chain to understand where the substances may be used.

Understanding where substances of concern are used, and at what concentration, in products and processes requires the participation of the entire supply chain. Determining substance information and ensuring that it is passed on by each actor in the A&D supply chain is a known challenge, one which IAEG have been actively working on for the last decade. IAEG WG1 focuses on materials and substance declarations, developing tools and guidance to aid this process. It is acknowledged that there are still steps to be made and obstacles to overcome in meeting this challenge.

[56] AEI. (2012). Boeing 787 Dreamliner assembly. Retrieved March 16, 2016, from https://www.aei.org/carpe-diem/boeing-787-dreamliner-assembled-in-the-us-made-on-earth/

[57] Only substances meeting the criteria in Article 57 of REACH

It is an issue known to A&D that full and detailed information on where substances of concern are used is often difficult to uncover, especially deeper in the A&D supply chain due to the complex geographical and contractual landscape. The visibility of process chemicals and intermediates is especially opaque.

For BPA, many uses are already known e.g., in resin and composite chemistry. The advantageous properties are exploited in a number of applications and the substance is sometimes visible due to its status as an SVHC. However, since BPA is predominantly used as an intermediate in polymer manufacture, it is not typically present at levels triggering disclosure to downstream recipients of BPA-polymer based products and formulations[58]. BADGE that is derived from BPA and used within many A&D applications, is not an SVHC. Therefore, it may be unknown in some instances if a component contains BPA or BPA derived substances, such as BADGE. This lack of immediate visibility can become an issue for the aerospace and defence industry due to the long transition time needed to introduce alternatives; without timely availability of substance information, dependencies could be obscured, and necessary action could be taken too late.

For BoSC, the understanding is much more limited. As with the case of BPA, where uses are intermediates for polymers and not present at levels triggering declaration, they may be obscured in the supply chain, even when they are also SVHCs. There is a large data gap in known uses of such substances that can only be filled by requesting information throughout the global supply chain. In practise some A&D companies report it takes typically around 24-36 months after a substance has been added to the REACH candidate list for the majority of the responses on those additions to be received from the global article supply chain.

The uses of BPA are relatively well understood by comparison. This is the result of a concerted effort by IAEG WG5 in an attempt to map the substance by engaging with the supply chain, surveying relevant trade associations, and direct one-to-one contact with key stakeholders[59]. This activity took place over a 2-year period. Due to the lack of declaration requirements for non SVHCs, to gain a more informed understanding of BoSC uses and article dependencies in the supply chain, it is likely a similar activity will need to be undertaken.

[58] Epoxy-Europe – Chemistry basics: https://epoxy-europe.eu/epoxies/chemistry-basics/ accessed June 2023
[59] IAEG WG5 - BPA supply chain mapping (2019) – proprietary to WG5

5 Residual Limits

5.1 Introduction

As is the case for the EU REACH restriction on BPA in thermal paper, an acceptable level of control of BPA and BoSC may be achieved by setting concentration limits for mixtures and articles. The withdrawn EU REACH Restriction proposal[17] also favoured this approach and proposed limits at 10 parts per million (ppm) level for presence of BPA and BoSC in mixtures and articles.

Understanding the residual levels of BPA and other BoSC will be of great importance to A&D OEMs; to determine compliance, should regulations require this in the future. Previous work undertaken by IAEG WG5 (BPA supply chain survey) focused primarily on uncovering and understanding uses of BPA in the sector and did not investigate BoSC or residual (<0.1%) levels of BPA or BoSC that may be present in articles. Additionally, it is possible that further A&D dependencies on BPA, where present only at residual levels in formulations and articles, may not have been identified.

5.2 Known residual limits across aerospace and defence

Following the publication of the previously withdrawn restriction proposal, activities to understand the residual levels of BPA within epoxy and polycarbonate products were undertaken by IAEG WG5 and RPA. These activities comprised of consultation activities with industry associations, formulators, and article manufacturers.

Information from the consultation conducted suggests an estimated 95% of polycarbonate products would comply with the previously proposed restriction conditions. Currently it is not well understood if the 5% of the potentially affected products can be reformulated successfully to reduce residual levels. It is also not established if there are A&D uses falling within the 5% of the potentially affected polycarbonate products.

LER and SER also had proposed derogation conditions within the withdrawn restriction proposal. Consultation with the supply chain indicated that most resins, SER and LER, would fall within a 65-ppm limit as set out previously in the withdrawn restriction proposal. Again, it is not yet established if there are A&D uses of LER or SER that would have a higher residual BPA concentration limit.

The initial concentration of residual BPA in a formulation will not be the same as in the cured final product. This is because some of the BPA is further reacted during curing, whilst the curing conditions will also impact the residual BPA concentrations. In short, the residual BPA in epoxy formulations will reduce during formulation and curing, but currently there is no data to verify by what amount. Therefore, it makes it difficult for formulators to predict with certainty how much BPA might be present in the final product.

Further supply chain work would be required, to try to ascertain residual levels in the polycarbonates and epoxy resins specifically used in A&D.

Currently there is no requirement to communicate residual concentrations for BPA through the supply chain. As such, this data is not currently available to A&D OEMs, and it is not possible to fully assess the impact of any such proposed restriction condition.

6 Conclusions

BPA and BPA derived substances, such as BADGE, are critical to the A&D industry being used in a vast majority of products and formulations. These products are relied upon to meet performance requirements dictated by OEMs and customers within the A&D industry. There are currently no known alternatives meeting these requirements. In any case, the process to replace materials in the A&D industry is subject to many rounds of testing and is expected to take several years. The extent of BPA uses in the industry are currently unknown but is considered to be significant. Previous supply chain mapping exercises undertaken by IAEG identified 6,000 material uses. The project was extremely time consuming and took 2 years to complete, it is expected that a similar exercise for BoSC identification would take the same amount of time or even longer. This is a result of supply chain complexities and lack of communication requirements for non-SVHCs. Whilst the level of risk is unknown in regard to BoSC, the extension mechanism of the proposed restriction leaves the A&D industry needing a full understanding of their supply chain.

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