ESPP DRAFT response to SCRREEN information request of 14/5/25:

CRM Act, Annex II, Section 2 for "Phosphorus" (P4 and derivates)

v. 26/5/25

Overall approach

For more information on the P4 industry, see SCOPE Newsletter n°136 (2020 validated by JRC and GROW).

a) P_4 and derivates

P_4 is produced (from phosphate rock, or possibly in the future from phosphate-containing wastes: EU funded Flashphos project https://flashphos-project.eu/). It is the non-substitutable initial raw material for the production of most organophosphorus chemicals, a range of phosphorus-chemical processes (e.g. phosphorus-doping of silicon to produce photovoltaic panels) and for soe specialist inorganic phosphate chemical applications (e.g. micro-chip etching, polymer fire safety).

However, P_4 as such is highly explosive, so it is sometimes not transported as P_4 but is converted into 'vector' chemicals, that is derivates which are less problematic to handle and transport and which retain the functional phosphorus reactivity of P_4 chemistry.

These derivates cannot be produced without P4 and are essentially "P_4 in a more amenable form".

We therefore suggest that CRM Annex II calculations for "Phosphorus" should address "P_4 and derivates".

Significant derivates of P_4 are

- With significant international trade: PMIDA, P_2O_5 (a single oxide, not a 'phosphate'), NaH_2PO_2, red P, H_3PO_4,
- Without significant international trade (because of handling risks, tend to be used mainly as on-site intermediates): PCl_3, P_2S_5, PH_3

SCOPE Newsletter n°136 includes a table of which end-use application can be reached via different P_4 derivates.

Thus, taking only customs data for EU imports of P_4 could be misleading, as some of the EU's use for the CRM "Phosphorus" is imported as derivates. However, customs data include "Phosphonates, phosphonites" which can include both basic chemicals (being imported as a P_4-vector for use in chemicals production) but also finished products (phosphonate or phosphonite flame retardants, phosphonates for water treatment …). Also, customs data do not enable to distinguish between phosphoric acid intended for use in electronics (chip etching, which can only be produced from P_4) and phosphoric acid being used for other applications for which acid coming from phosphate rock via the "wet acid" route could be used -see below (eg. food phosphates).

Overall, customs data suggest that probably 80% or more of relevant P_4 and derivates imports into the EU are in fact as P4 (white, yellow, red or black phosphorus).

b) “Phosphorus” and “Phosphate Rock”

For discussion of the CRM “Phosphorus” (meaning P_4 and derivates) it is essential to distinguish between uses which can be fulfilled by purification of phosphoric acid (that is, coming from phosphate rock by the ‘wet acid’ route without input of P_4) and uses which necessitate input of P4 (produced by the thermal P4 furnace route).

To simplify, inorganic phosphates can be produced from purified phosphoric acid (from Merchant Grade Acid, or “green acid”, from phosphate rock), whereas most organophosphorus chemicals cannot - but, there are important exceptions, see below.

For example, the cathodes of LFP batteries (lithium iron phosphate, currently the widest used battery technology in both vehicles and in energy storage), are $LiFePO_4$ (inorganic). This can be produced without P_4, from purified phosphoric acid (highly purified = battery grade). On the other hand, lithium hexafluorophosphate ($LiPF_6$), which is an important constituent of the polar organic solvent electrolytes of all commercial lithium ion batteries, is an organophosphorus compound which can only be produced from P_4 and derivates.

Visibility is complicated because in the past, and still in parts of the world today, P_4 was and is used to produce inorganic phosphates, including detergents, food phosphates, etc. This has largely disappeared (except where necessary, see exceptions below) because of the high energy costs of producing P_4 and because phosphoric acid purification technologies can today achieve food or battery grade purity (“thermal” phosphoric acid from P4 is inherently of extremely high purity). In particular, even today and possibly in Europe, some companies continue to produce inorganic food additive phosphates from P_4-derived phosphoric acid. European industry leaders however consider that this is no longer necessary, because acid purification can achieve food grade quality.

Exceptions: **inorganic phosphate compounds / applications which necessitate P_4 and derivates:**

- **Inorganic phosphorus flame retardants used in plastics / polymers / composites**
  Any water content in such materials results in deterioration of mechanical properties (plastics are hydrophobic) and of electrical insulation and surface electrical transmission resistance (critical in electrical and electronics, electric vehicles, batteries … - and required by industry specifications such as Comparative Tracking Index CTI).
  Production from P4 and derivates (e.g.. P_2O_5) results in ‘zero’ humidity. This is not possible by production from phosphoric acid because drying of phosphoric acid chemically stops at concentrated polyphosphoric acid, which still contains water.

- **Phosphoric acid used for microchip etching**
  Because chip circuits are today at the ‘atomic’ scale, effectively zero impurities are necessary. This level of purity cannot realistically be achieved by acid purification so P4-derived “thermal” acid is necessary.

- **Inorganic chemical applications requiring phosphorus valency <5**
  E.g. cuprophoshorus ($CU_3P)_2$ for specialised metal alloys), phosphorus doping of silicon for photovoltaic panels, phosphorus doping of semiconductors for electronics …

Further explanation in [SCOPE Newsletter n°136]

c) Strategic uses of P4 and derivates

P4 and derivates are essential for the following applications:

* = “Strategic” = essential for “strategic technologies” as defined in the CRM Act art . 2 (Definitions) $30: “*strategic technologies’ means the key technologies instrumental for the green and digital transitions as well as for defence and aerospace applications*”

- * Phosphorus-based flame retardants and fire protective coatings (for metal or timber structures, seals and joints …) – essential for electrical and fibre optic cables, connectors, switches, electrical and electronics system casings, batteries, photovoltaic panels and other renewable energy installations, aircraft …
- Metal production: for example, separation of cobalt (an EU Critical Raw Material) from nickel during metals production depends on the P4 derivative thiophosphinates
- * P4 “thermal” phosphoric acid for micro-chip etching (electronics)
- * Lubricants, in particular for jet engines: e.g. ZDDP (zinc dialkyl dithiophosphates) or alkyl phosphate mono- and di-esters
- Oil and gas extraction: phosphonates
- Petrochemical industry: phosphorus catalysts
- * Cooling water circuits and cleaning: phosphonates (e.g. for data centres)
- Speciality chemicals: e.g. BAPO photo-initiators (photo-curable polymers, coatings and adhesives)
- * Performance metal alloys, used in transport applications and in electronics: e.g. cuprophosphorus used to produce performance alloys such as phosphor-bronze, used in e.g. electrical contacts.
- * Batteries: lithium ion battery electrolytes ($LiPF_6$)
- * Photovoltaic panels (PV): doping of n-silicon
- * Semiconductor doping (electronics): phosphine

Point 1 = economic importance (EI) and Point 2 Substitution index

- *s denotes the NACE (2-digit level) sectors of the economy*
- *A_s is the share of end use of the assessed raw material in a NACE (2-digit level) sector (using Union values when available, global shares otherwise*
- *Q_s is the value added of the relevant sector at the NACE (2-digit level), as a share of the total economy → to be provided by EC*
- *SI_{EI} is the substitution index related to economic importance → comes from calculation in Point 2.*
- *$SPP_{i,a,EI}$ is the Economic Importance performance parameter of each substitute material, i, compared to the assessed raw material, based on technical performance, including functionality, and cost performance, for each application, a*
- *$Share_a$ is the share of the raw materials in an end-use application*
- *$Sub\_share_{i,a}$ is the sub-share of each substitute material within each application.*
- *$SPP_{i;SR}$ (Point 6) is the Supply Risk performance parameter of each substitute material, i, based on its global production, criticality and economic significance (primary product, co-product, by-product).*

	NACE code = s	**Annual tonnage P (world) = A_s**	**% of P4 + derivate use**	**Substitutes**	**$SPP_{i,a,EI}$ (Point 2)**	**$SPP_{i;SR}$ (Point 6)**	**$Share_a$**	**$Sub\_share_{i,a\,Ei}$**
Separation of cobalt (an EU Critical Raw Material) from nickel during metals production depends on the P4 derivative thiophosphinates	C24 - Manufacture of basic metals				No substitute for P4			
Cuprophosphorus (from P4) is used to produce performance alloys such as phosphor-bronze, used in e.g. electrical contacts.	C25 - Manufacture of fabricated metal products, except machinery and equipment				No substitute for P4			
Electronics: P4 "thermal" phosphoric acid for micro-chip etching, phosphine for semiconductor doping	C26 - Manufacture of computer, electronic and optical products				No substitute for P4			
Lubricants, in particular for jet engines: e.g. ZDDP zinc dialkyl dithiophosphates or alkyl phosphate mono- and di-esters	C19 - Manufacture of coke and refined petroleum products.				Other lubricants ?			
Oil and gas extraction: phosphonates	B6 - Extraction of crude petroleum and natural gas; B9 - Mining support service activities				Other additives ?			
Petrochemical industry: phosphorus catalysts	C19 - Manufacture of coke and refined petroleum products; C20 - Manufacture of chemicals and chemical products				No substitute for P4			
Industry cooling water circuits: phosphonates	C20 - Manufacture of chemicals and chemical products, C28 - Manufacture of machinery and equipment n.e.c.	20 000 tP/y			???			
Detergents: phosphonates	C20 - Manufacture of chemicals and chemical products				Not relevant for 'Strategic' industry sectors			
Speciality chemicals: e.g. BAPO photo-initiators	C20 - Manufacture of chemicals and chemical products				No substitute for P4			
Performance metal alloys: cuprophosphorus	C24 - Manufacture of basic metals				No substitute for P4			
Photovoltaic panels (PV): doping of n-silicon.	C27 - Manufacture of electrical equipment				No substitute for P4			
Agrochemicals	C20 - Manufacture of chemicals and chemical products	150 000 tP/y			Not relevant for 'Strategic' industry sectors			
Batteries (electrolytes LiPF6)	C27 - Manufacture of electrical equipment	10 000 tP/y			No substitute for P4			
Matches and pyrotechnics	C32 - Other manufacturing				Not relevant for 'Strategic' industry sectors			
Pharmaceuticals	C21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations							
Military applications: explosives, chemicals, other	C32 - Other manufacturing	Confidential						
Fire safety	***See below***							

Fire safety: flame retardants and intumescent paints/coatings	Applications	**NACE code = s**		
	Textiles – consumer, protective fire-protective, carpets, curtains, textiles for transport seats (cars, ships, trains, aircraft), technical textiles) …	C13 - Manufacture of textiles C14 - Manufacture of wearing apparel	Total world annual use of P4 & derivates: 50 000 tP/y	***Ventilation of use between applications, substitutes: see below***
	Wood and timber	C16 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials		
	Technical and building paper applications require fire safety	C17 - Manufacture of paper and paper products		
	Plastics, polymers, composites, rubbers, etc	C22 - Manufacture of rubber and plastic products		
	Consumer electronics and consumer electrical appliances, printed circuit boards …	C26 - Manufacture of computer, electronic and optical products		
	Industrial electrical equipment, Optic cables, Electrical cables, Batteries, PV panels and renewable energy, etc.	C27 - Manufacture of electrical equipment		
	Industrial machinery, escalators, conveyor belts	C28 - Manufacture of machinery and equipment n.e.c.		
	Road transport: cars and lorries	C29 - Manufacture of motor vehicles, trailers and semi-trailers		
	Trains and stations, Ships, Aerospace	C30 - Manufacture of other transport equipment		
	Furniture	C31 - Manufacture of furniture		
	Application during construction / renovation of fire protective paints and coatings	F41 - Construction of buildings F42 - Civil engineering F43 - Specialised construction activities		

Substitutes for phosphorus flame retardants:

Halogenated flame retardants	Tending to be phased out for environment and health reasons.
Nitrogen flame retardants	Less effective
Inorganic flame retardants	Less effective/
Halogenated flame retardants	Tending to be phased out for environment and health reasons.
Use non combustible materials (e.g. metals to replace plastics or composites)	Generally not feasible/ appropriate.
Inherently poorly-flammable polymers	Obstacles of cost, performance characteristics
Other ?	

Point 3 = economic importance (EI) and Point 2 Substitution index

GS denotes the global annual production of the assessed raw material;	0.6 MtP/y	P4 represents around 3% of 20 MtP/y (total phosphate production) from www.phosphorusplatform.eu/Scope136
EU sourcing denotes the actual sourcing of the supply to the Union, i.e. Union domestic production plus Union imports from third countries or from OCTs;	See data under Point 4	
HHI is the Herfindahl-Hirschman Index (used as a proxy for concentration of supply across countries);	Calculated in Point 5	Supply to Europe: Kazakhstan Vietnam China = today nearly zero USA = today nearly zero
WGI is an index based on the scaled World Bank Worldwide Governance Indicators (used as a proxy for country governance);	Kazakhstan = Vietnam = China = USA =	
tc is the trade parameter adjusting WGI, which shall be determined taking into account potential export taxes (possibly mitigated by a trade agreement in force), physical export quotas or export prohibitions imposed by a country, c.		
EoLRIR is the end-of-life recycling input rate, meaning the ratio of secondary material inputs (recycled from old scrap) to all inputs of a raw material (primary and secondary);	Zero	P4 cannot be "recycled" as such. P4 could be produced from secondary materials, but this is not today operational and in any case is not relevant for EoLRIR
SISR is the substitution index related to supply risk;		
IR is import reliance.	Calculated in Point 4	

Point 4 = Import Reliance (IR)

EU production		Zero
EU imports	Total EU imports of P4 and of P4 derivates (vector chemicals, such as PCl3, PMIDA, PMIDA, P2O5, NaH2PO2, red P, H3PO4,).	
EU exports		Negligible

Point 5 - Herfindahl-Hirschman Index HHIWGI

c denotes the countries supplying the assessed raw material;	Kazakhstan	Vietnam	China	USA
S_c is the share of country c in the supply (GS or EU sourcing) of the assessed raw material;				
WGI_c is an index based on the scaled World Bank Worldwide Governance Indicators of country c;	World Bank indicator			
t_c is the trade parameter of a country adjusting the WGI, which shall be determined taking into account potential export taxes (possibly mitigated by a trade agreement in force), physical export quotas or export prohibitions imposed by a country c.	No obstacles to date	No obstacles to date	Export taxes / quotas	Risk of tariffs. In any case little export (US P4 production is mainly directly used by producer company)

Point 6 – Substitution Index SISR

i denotes an individual substitute material;	See table under Point 1
a denotes an individual application of the candidate material;	
$SPP_{i;SR}$ is the Supply Risk performance parameter of each substitute material, i, based on its global production, criticality and economic significance (primary product, co-product, by-product);	

$Share_a$ is the share of the candidate materials in an end-use application;	
$Sub\_share_{i,a}$ is the sub-share of each substitute material within each application.	