POLYCHLORINATED NAPHTHALENES

July 2002

NATIONAL INDUSTRIAL CHEMICALS NOTIFICATION AND ASSESSMENT SCHEME
GPO Box 58, Sydney NSW 2001, Australia www.nicnas.gov.au

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1. INTRODUCTION

1.1 Nomination reason

The chemical group polychlorinated naphthalenes (PCNs) was nominated during the National Industrial Chemicals Notification and Assessment Scheme's (NICNAS) public call for nomination of chemicals of concern in February 1999.

The reason for nomination and selection of these chemicals for further work included concerns surrounding their potential to persist and bioaccumulate in the environment.

An initial call for information under section 48 of the *Industrial Chemicals (Notification and Assessment) Act 1989* (Cwlth) (the Act) was carried out for PCNs in August 1999. No information was received by NICNAS as a result of this call for information.

1.2 Objectives of report

The objectives of the report are to identify the quantities of PCN or PCN products imported into Australia, quantities of PCN manufactured here and uses of PCNs and PCN products. Amounts of PCNs produced and/or released as by-products of processing and/or manufacture and use were also investigated.

In addition to the uses and amounts, the report includes information on the physico-chemical characteristics of these chemicals and overseas regulatory initiatives pertaining to these chemicals.

2. SEARCH STRATEGY

2.1 Industry

In accordance with section 48 of the Act, a notice was published in the *Commonwealth Chemical Gazette* of January 2002. Eight generic groups of PCNs were identified and published in the call for information notice. The notice was directed at all persons who have manufactured or imported one or more of the chemicals or products containing the listed chemicals since August 1999. The information required in the section 48 notice was:

- quantities imported and/or manufactured;
- amounts produced and/or released as by-products of processing and/or manufacture;
- products imported containing the chemicals and quantities of the chemicals in the products; and
- uses of the chemicals or the products containing the chemicals.

It also encouraged any other persons with information on these chemicals including users, past importers or manufacturers to provide this information.

A total of 27 companies identified as being potentially involved with this group of chemicals were contacted. The companies are listed in Appendix 1.

Potential manufacturers and importers of these chemicals were identified from a search of:

- overseas use information;
- published literature (eg books, manuals and encyclopaedias);
- Australian Customs Service;
- NICNAS Company Registration Database (NICNAS, 2002); and
- web site sources such as MSDSOnline (MSDSOnline, 2002), SciFinder (SciFinder, 2000) and TOMES Plus (TOMES Plus, 2002).

Throughout this process if information became available on a particular use, or, industry that may use, or be associated with the chemical, then further focused searching was conducted in that specific area.

2.2 Customs

Customs Tariff Code data allows for the identification of certain groups of chemicals imported into Australia. Data for PCNs was obtained under a generic Customs Tariff Code found to be the most relevant for these chemicals. This information was used to identify potential importing companies.

2.3 Organisations

Organisations contacted included non-government organisations (NGO) including industry associations and unions (Appendix 2) as well as government agencies at the Federal, State and Territorial levels.

NGOs were identified from the Directory of Australian Associations March 2002-July 2002 (Current Contents, 2002).

In addition, agencies such as the United States Environmental Protection Agency (US EPA) and the European Chemicals Bureau were contacted for likely use information.

2.4 Literature Sources

Chemical identity searching was conducted using a variety of databases to identify other chemicals within this group. SciFinder (2000) was used to identify chemicals with the same molecular structure, and chemical dictionaries and encyclopaedias were used to further identify the specific chemical constituents within the eight groups of PCNs.

3. CHEMICAL IDENTITY

PCNs are a group of theoretically 75 possible chlorinated naphthalenes, containing one to eight chlorine atoms bound to the naphthalene di-benzene ring (IPCS, 2001). These are structurally similar to polychlorinated biphenyls (PCBs) (Van de Plassche, 2002). Eight groups are listed in Table 1.

Table 1: Names and CAS Numbers for PCN groups

PCN Name	CAS Number	Molecular formula
Monochloronaphthalene	25586-43-0	$C_{10}H_7Cl$
Dichloronaphthalene	28699-88-9	$C_{10}H_6Cl_2$
Trichloronaphthalene	1321-65-9	$C_{10}H_5Cl_3$
Tetrachloronaphthalene	1335-88-2	$C_{10}H_4Cl_4$
Pentachloronaphthalene	1321-64-8	$C_{10}H_3Cl_5$
Hexachloronaphthalene	1335-87-1	$C_{10}H_2Cl_6$
Heptachloronaphthalene	32241-08-0	$C_{10}HCl_7$
Octachloronaphthalene	2234-13-1	$C_{10}Cl_8$

Further groups of PCNs can be made as combinations of the eight groups identified in Table 1 but with differing proportions such as the commercial mixtures listed in Table 3. Larger generic groups also exist such as the generic group covering tetra-, penta-, hexa-, hepta- and octachloronaphthalene, that is polychlorinated naphthalenes with greater than 3 chlorines (CAS 70776-03-3).

Figure 1: Structure and naming convention for the polychlorinated naphthalenes.

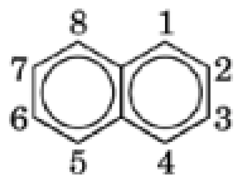
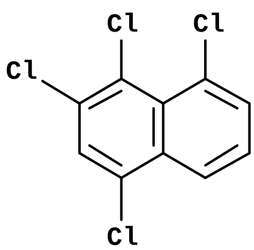


Figure 2: 1,2,4,8-tetrachloronaphthalene(CAS 6529-87-9)



Chemical formula

$C_{10}H_{8-n}Cl_n$

Product trade names

A number of commercial products containing various concentrations of PCNs were used in the past. Trade names for these products were Halowax, Nibren Waxes, Seekay Waxes and Cerifal Materials, N-Oil (Van de Plassche, 2002; Holoubek et al., 2000). Refer to Table 3 for their composition and uses.

4. CHEMICAL AND PHYSICAL PROPERTIES

Most industrially produced PCNs were mixtures of several isomers of PCNs (IPCS, 2001). The commercial products ranged from low viscosity oils to high melting point solids with intermediate waxlike solids varying in crystallinity and melting point (IPCS, 2001).

PCNs have physical and chemical properties largely similar to those of PCBs. They are hydrophobic, have high chemical and thermal stability, good weather resistance, good electrical insulating properties and low flammability and are compatible with other materials (Holoubek et al., 2000; Falandysz, 1998).

PCNs have low flammability and have a medium to low volatility. The chemical and physical properties of PCNs are outlined in Table 2.

Table 2: Chemical and physical properties of polychlorinated naphthalenes. (Adapted from IPCS, 2001)

Group	**Molecular Weight**	**Melting Point** (°C)	**Boiling Point** (°C)	**Water Solubility** (mg/l)	**Vapour Pressure** (kPa)	**Henry's Law Constant** (Pa.m³/ mole)	**LogK$_{OW}$** (Octanol/ water partition coefficient)
Mono	162.61	-2.3-60	260	0.28 – 9.2 x10^{-2}	2.1x 10^{-3} - 3.9 x 10^{-3}	36	3.9
Di	197	37-138	285-298	8.5 x10^{-3} – 8.6 x10^{-2}	1.7 x 10^{-3}	Not available	4.19-6.93
Tri	231.5	68-133	ca. 274	1.6 x10^{-2} – 6.7 x10^{-2}	1.3 x 10^{-4}	Not available	5.35-7.56
Tetra	266	115-198	Not available	3.7 x10^{-2} – 8.0 x10^{-2}	Not available	Not available	5.50-8.58
Penta	300.4	147-171	ca. 313	7.3 x10^{-3}	4.2 x 10^{-6}	11.9	8.73-9.06
Hexa	335	194	ca. 331	1.1 x 10^{-4}	9.5 x 10^{-7} - 3.0 x 10^{-9}	8.8	6.98-10.37
Hepta	369.5	194	ca. 348	4.0 x 10^{-5}	3.7 x 10^{-7}	Not available	7.63-8.3
Octa	404	192	440	8.0 x 10^{-5}	1.3 x 10^{-7}	4.8	Not available

ca. = circa: denotes an estimated or calculated value

A report commissioned by the United Nations Economic Commission for Europe (UN ECE) noted that increasing chlorination of PCNs mirrors an increasing octanol-air partition coefficient (log K_{OA}). This indicates that higher chlorinated PCNs are potential candidates for long-range airborne transport due to their increasing affinity to escape from water. There is also a potential for air containing these higher chlorinated PCNs to progress towards cooler regions where condensation of the PCN molecules is caused by the decreasing temperatures of the surroundings (Van de Plassche, 2002).

5. INTERNATIONAL PERSPECTIVES

Commercially produced mixtures of PCNs became popular after 1910 because of their flame retardant and dielectric properties (Hayward, 1998). Production slumped post World War 2 because flame retardant plastics were being developed and PCBs were used as dielectrics (Hayward, 1998). Volumes decreased in the late 1970s because of the growing evidence that PCNs were becoming a pollutant on a global scale (Van de Plassche, 2002).

5.1 Uses and emissions

No natural sources of PCNs have been identified (IPCS, 2001). Anthropogenic sources are:

- PCN formulation;
- PCB formulation; and
- thermal and other processes in the presence of chlorine.

PCN formulation

PCNs are manufactured by metal-halide catalysed chlorination of molten naphthalene at a temperature slightly above the melting point of the desired product. The crude chlorinated naphthalenes are then treated with soda ash or caustic soda, fractioned under reduced pressure and purified with activated clay (Van de Plassche, 2002).

Between 1910 and 1960 the United States (US) production of PCN formulations was estimated to be between 50 000 to 150 000 metric tons (Hayward, 1998). During the 1920s approximately 9000 tonnes/year was produced in the US. From 1930 to the 1950s PCNs were used extensively and production in 1956 was estimated at 3200 tonnes. By 1978 production in the US had fallen to 320 tonnes/year. The production of PCNs in the US stopped in 1980 and only small quantities, approximately 15 tonnes/year were used in 1981 (IPCS, 2001).

In the United Kingdom the production of PCNs is reported to have ceased in the mid 1960s. Around 300 tonnes were produced in Germany in 1984 mainly as dye intermediates until 1989 when production was stopped (IPCS, 2001).

The end uses for PCNs covered a wide variety of industries and specific uses have been reviewed by a number of authors (IPCS, 2001; Falandysz, 1998; Hayward, 1998; Van De Plassche, 2002; Holoubek, 2000). Past uses included:

- cable insulation
- wood preservatives
- engine oil additives
- other lubricant uses

- electroplating masking compounds
- feedstock for dye production
- dye carriers
- capacitor fluids
- refractive index testing oils
- flame proofing
- preservatives
- moisture proofing sealant
- temporary binders for ceramic component manufacture
- casting material for alloys.

The lower chlorinated PCN mixtures were used predominantly as lubricants whereas the higher chlorinated mixtures were used for capacitor impregnation and electrical insulation. Commercial production of these mixtures ceased in 1980 (IPCS, 2001). Table 3 contains a list of the previously manufactured commercial PCN mixtures with their composition and properties.

Table 3: Chemical composition and properties of commercial PCN mixtures (from IPCS, 2001)

Chlorinated naphthalene	CAS No.	Chlorine content (%)	Chlorinated naphthalene composition (% weight)	Boiling point (°C)	Melting point (°C)	Vapour pressure (kPa)	Aqueous solubility	Henry's law constant (Pa·m^3/mol)
Halowaxes								
Halowax 1031	25586-43-0	22	95% mono-, 5% di-	250	-25	1.9×10^{-3}	Insoluble	31.9
Halowax 1000	58718-66-4	26	60% mono-, 40% di-	250	-33		Insoluble	
Halowax 1001	58718-67-5	50	10% di-, 40% tri-, 40% tetra-, 10% penta-	308	98		Insoluble	
Halowax 1099	39450-05-0	52	10% di-, 40% tri-, 40% tetra-, 10% penta-	315	102		Insoluble	
Halowax 1013	12616-35-2	56	10% tri-, 50% tetra-, 40% penta-	328	120		Insoluble	
Halowax 1014	12616-36-3	62	20% tetra-, 40% penta-, 40% hexa-	344	137		Insoluble	
Halowax 1051		70	10% hepta-, 90% octa-		185			
Nibren waxes								
D88					90			
D116N					113			
D130					135			
Seekay waxes								
68 (R Grade)		46.5						
93 (R Grade)		50						
123 (R Grade)		56.5						
700 (R Grade)		43						
93 (RC Grade)		50						
123 (RC Grade)		56.5						
Clonacire waxes								
90					90			
115					115			
130					130			

PCB formulations

PCNs occur as contaminants in PCB mixtures as they are formed during similar manufacturing practices. PCN contamination values in PCBs range from 3.5 to 731 μg/g (Van de Plassche, 2002). Median values of 0.0067% PCN contamination of PCB mixtures (Aroclor and Clophen series) have been reported (Holoubek et al., 2000). Using total worldwide production of PCBs (ca. 1 500 000 metric tonnes), a value of 100 metric tons of PCN produced as a contaminant in PCB mixtures was calculated by Holoubek et al (2000). However, up to 169 tonnes have been reported by other authors (Van de Plassche, 2002). All PCNs in PCB formulations are not likely to be released due to safer technologies for disposal and management of the used PCBs (Holoubek et al., 2000).

Thermal and other processes

PCNs are formed in thermal heating and burning processes, of which waste incineration is the most important (Van de Plassche, 2002). Sixty eight of the 70 isomers of PCN have been measured in flue gas samples from municipal solid waste incinerators (Falandysz, 1998).

Reclamation and smelting of aluminium and copper ore roasting may result in PCN emissions (Flandysz, 1998).

The major current sources of PCNs are likely to be emissions from municipal and special waste incinerators and disposal of items containing PCNs to landfill (IPCS, 2001).

5.2 International initiatives

By comparison with PCBs, little is known about PCNs which have had very similar uses in the past. While no environmental regulatory action seems to have been undertaken for PCNs, there is increasing evidence that they are widespread pollutants.

United States (US)

The American Conference of Governmental Industrial Hygienists (ACGIH) sets exposure standards for various chemicals. These standards are set as short term exposure limit (STEL) for periods up to 15 minutes and a threshold limit value (TLV) as a time weighted average (TWA) for a 8-hour workday and a 40-hour working week (ACGIH, 2000).

The Occupational Safety and Health Administration (OSHA) sets permissible exposure limits (PEL) for chemicals as a TWA (8 hours) and also a STEL for 15-minute exposure (US Dept of Health and Human Service, 1995).

The National Institute for Occupational Safety and Health (NIOSH) establishes a recommended exposure limit (REL) as a TWA and STEL. NIOSH may also establish an immediately dangerous to life and health (IDLH) value.

Table 4 lists the US standards for PCNs.

Table 4: US exposure standards for PCNs

Organisation	ACGIH		OSHA		NIOSH		
Exposure Standard	**TLV TWA** (mg/m^3)	**STEL** (mg/m^3)	**PEL TWA** (mg/m^3)	**STEL** (mg/m^3)	**REL TWA** (mg/m^3)	**STEL** (mg/m^3)	**IDLH** (mg/m^3)
Tri	5.0 *	Not set	5.0 *	Not set	5.0 *	Not set	Not set
Tetra	2.0	Not set	2.0*	Not set	2.0 *	Not set	Not set
Penta	0.5 *	Not set	0.5 *	Not set	0.5 *	Not set	Not set
Hexa	0.2 *	Not set	0.2 *	Not set	0.2 *	Not set	2.0
Octa	0.1 *	0.3 *	0.1 *	0.3	0.1 *	0.3 *	Not set

* skin notation

European Union

The European Union has classified pentachloronaphthalene as a hazardous substance under their regulations. Table 5 contains the classification and risk phrases assigned to pentachloronaphthalene.

Table 5: EU classification and corresponding risk phrases for pentachloronaphthalene.

EU Risk Phrases
Harmful (Xn)
• R21/22 - Harmful in contact with skin and if swallowed
Irritant (Xi)
• R36/38 - Irritating to eyes and skin.
Environmental (N)
• R50 - Very toxic to aquatic organisms.
• R53 - May cause long term adverse effects in the aquatic environment.

Germany has set a MAK[1] of 5 mg/m^3 for both trichloronaphthalene and tetrachloronaphthalene.

All halogenated naphthalenes are legally banned in Switzerland (personal communication Swiss Department of Environment as cited in Van de Plassche, 2002).

[1] MAK (Maximale Arbeitsplatzkonzentration) is the maximum concentration of a substance in the ambient air in the workplace that has no adverse effect on the worker's health in Germany.

6. AUSTRALIAN PERSPECTIVES

6.1 Uses and emissions

Ten companies (37%) and 2 associations/unions who were sent the section 48 notice responded to the call for information. In addition, 11 further companies responded directly to the section 48 call for information.

Data on imports and uses obtained are presented in Table 6. Data on importation was provided for the two members of the monochloronaphthalene group only. Volumes reported were for the period 1998 to early 2002.

Table 6: Uses and quantities of PCNs

CAS Number	Chemical Name	Quantity (grams)	Use
90-13-1	1-chloronaphthalene	6795	Scientific research
91-58-7	2-chloronaphthalene	1.0	Scientific research

End users were contacted for further elaboration on use information. The uses identified are as follows:

1-chloronaphthalene

- immersion of oils for refractive index testing;
- reagent used in renal calculi analysis;
- calibration standard in water discharge analysis;
- testing for ferric oxide in water samples;
- identification of polypropylene in water samples; and
- molecular architecture to create novel compounds.

2-chloronaphthalene

- analytical standard.

A polychloroprene polymer was identified as containing PCNs as incidentally produced chemicals. Table 7 outlines concentrations of the specific PCNs in the polychloroprene polymer.

Table 7: Concentration of PCNs present in the polychloroprene polymer

CAS Number	Chemical Name	Concentration (%)
1321-65-9	Trichloronaphthalene	3.0
1335-88-2	Tetrachloronaphthalene	1.0
1321-64-8	Pentachloronaphthalene	0.2
TOTAL		**4.2**

The polychloroprene polymer was used as an additive during the manufacture of cable insulation. Use of this polymer in this application ceased in May 2002. An alternative is now being used by the Australian cable manufacturer. Internationally the production of the polychloroprene polymer ceased in 2002.

From 1986 to 2002 approximately 7 tonnes per annum of the polychloroprene polymer was brought into Australia. Based on the total quantity of PCNs in the product, outlined in Table 7, the total amount of PCNs coming into Australia via this product alone totals 4.6 tonnes.

It is likely that these chemicals may have been imported into Australia as components of other products such as engine and lubricant oils, capacitor fluids or incorporated into articles. Articles that have been in use for some time such as insulated cables and flame and moisture proofed material may contain PCNs bound into the matrix. Information regarding binding and mobility out of the matrix is unknown.

Concerns regarding the long-term effects of PCNs within Australia relate to PCNs with two or more chlorine atoms. However, based on the lack of data supplied in August 1999 and during the latest call for information these do not seem to have been manufactured in Australia. Products containing some of the higher chlorinated PCNs have been imported into Australia with importation ceasing in May 2002.

Because PCNs were a contaminant in PCBs it is likely that the amount of PCNs could be calculated based on the Australian data held for PCBs. According to Environment Australia's (2001) PCB Review Panel estimates of PCB quantities within Australia are unknown. However, the Electricity Supply Association of Australia estimated that some 10 000 to 20 000 tonnes of PCBs had been imported for use in Australia but estimates remained very imprecise (Environment Australia, 2001). Using the maximum amount of PCBs imported and the PCN impurity concentration of 0.0067% as reported by Holoubek et al. (2001), an amount of 1.34 tonnes of PCNs as impurities is obtained.

Currently, Australia has no municipal waste incineration facilities. The last municipal incineration facility in Australia closed in 1996 when the Sydney based Waverly-Woollahra Process Plant was shut. The closure occurred because of pollution and public health concerns (Lycos, 2000). Two new incineration facilities to deal with the municipal wastes in Western Australia and Tasmania have been granted environmental approvals by the relevant authorities. However, construction of these facilities has not begun because waste sources, cost of operation and remaining permits are still to be finalised. Internationally municipal incineration facilities have been indicated as a current source of PCN emissions to the environment. The other source is the landfill disposal of PCN containing wastes. The amounts and impact of this source cannot be gauged.

PCNs are released from similar processes as dioxins for which limited information exists in Australia. Environment Australia is currently conducting a project to estimate dioxin releases in Australia. The results of this project may contain relevant information on PCNs within Australia.

No other local emissions data was obtained. The industries contacted were unable to supply information relating to previous or current uses or emissions.

6.2 Regulatory controls

The monochloronaphthalene, 1-chloronaphthalene (CAS 90-13-1), and octachloronaphthalene (CAS 2234-13-1) are listed in the Australian Inventory of Chemical Substances (AICS). Also included in AICS is a generic group of polychlorinated naphthalenes, polychlorinated naphthalenes covering members in the group with greater than 3 chlorines (CAS 70776-03-3) (AICS, 1999).

Although 2-chloronaphthalene is not listed in the AICS the chemical may be imported into Australia under an exempt category for research and development purposes. Octachloronaphthalene has not been imported into Australia since August 1999. Polychlorinated naphthalenes (greater than 3 chlorines) are not used in current formulations, based on the information supplied by the notifying company. However listing of these chemicals in the AICS indicates that these were either manufactured or imported into Australia during the period 1 January 1997 to February 1990.

The National Occupational Health and Safety Commission (NOHSC) has set exposure standards for some of the PCNs. These are outlined in Table 8. Tri-, hexa- and octachloronaphthalene also have a skin notation, which indicates that absorption through the skin may be a significant source of exposure. These exposure standards were adopted from the ACGIH.

Table 8: Exposure standards set for PCNs

	TWA	STEL	Skin notation
Tri	5.0	Not set	Yes
Tetra	2.0	Not set	No
Penta	0.5	Not set	No
Hexa	0.2	Not set	Yes
Octa	0.1	0.3	Yes

Tri-, tetra-, penta-, hexa- and octachloronaphthalenes are included in the NOHSC *List of Designated Hazardous Substances* (NOHSC, April 2002). The basis for inclusion of tri-, tetra-, hexa- and octachloronaphthalene in the list as hazardous substances is that they have been assigned exposure standards.

Pentachloronaphthalene is currently classified by NOHSC as a hazardous substance. Table 9 contains NOHSC classification and corresponding risk phrases for pentachloronaphthalene. This classification is adopted from the EU by NOHSC.

Table 9: Classification of pentachloronaphthalenes.

Risk Phrases

Harmful (Xn)

- R21/22 - Harmful in contact with skin and if swallowed

Irritant (Xi)

- R36/38 - Irritating to eyes and skin.

Environmental (N)*

- R50 - Very toxic to aquatic organisms.
- R53 - May cause long-term adverse effects in the aquatic environment.

***** Environmental risk phrases are not mandatory within Australia.

PCNs are not specifically classified as dangerous goods in the *Australian Code for the Transportation of Dangerous Goods by Road and Rail* (FORS, 1998). PCNs are also not specifically listed in the *Standard for the Uniform Scheduling of Drugs and Poisons (SUSDP)* (NDPSC, 2001).

According to the National Registration Authority, none of the PCNs have been registered as pesticides or as components of pesticides within Australia.

PCNs have not been considered to date by the Commonwealth Scheduled Waste Management Group in relation to the need for disposal of persistent organochlorine compounds. This indicates that little or no PCNs are stockpiled in Australia.

PCNs are not listed in the National Pollution Inventory hence they do not require reporting.

7. CONCLUSIONS

Global production from all sources of PCNs may have been approximately 150 000 metric tons from 1910 to 1960. The majority of this was produced as mixtures of PCNs for various uses. From the data obtained during this assessment the specific PCNs imported into Australia are 1-chloronaphthalene and 2-chloronaphthalene. It appears that other PCNs were imported into Australia as contaminants in products or articles. Industries previously involved with these chemicals have confirmed that manufacture and use of them has stopped.

Internationally the uses of PCNs have been as components of a number of products such as engine oils, lubricants and capacitor fluids and articles such as cable insulation, preserved wooden items, ceramic components and flame and moisture proofed items.

Products and articles containing PCNs, other than those identified, were brought into Australia during the years of increased international use. Some of those products and articles may still be in use today, but no data was submitted to quantify leaching rates from the products or articles manufactured with PCN contaminated products. Based on international trends it is likely that the amount of PCNs coming into Australia in products and articles will be reduced.

Contamination by PCNs of PCB mixtures poses a potential source of continued exposure for the Australian environment. However, the current disposal techniques for PCBs should remove this source over time.

8. FOLLOW-UP ACTION

Octachloronaphthalene is specifically listed in the AICS. However, no information was provided for octachloronaphthalene indicating that importation and/or manufacture of the chemical may not be occurring in Australia. Octachloronaphthalene, along with other PCNs, have been identified as contaminants in PCB mixtures and other products. In addition, PCNs have also been identified as being structurally similar to PCBs and are formed during the same processes.

Given that only 37% of companies identified as potential importers or manufacturers of PCNs including octachloronaphthalene responded to the section 48 notice, NICNAS will explore options to track importation and/or manufacture of octachloronaphthalene in Australia.

APPENDIX 1: List of Companies Contacted

Alpha Chemicals (Australia) Pty Ltd

AS Harrison & Co Pty Ltd

Bostik Findlay Australia Pty Ltd

Bribros Australia Pty Ltd

Caltex Australia Limited

Chemlube Company Pty Ltd

Chem-Supply Pty Ltd

Ciba Speciality Chemicals Pty Ltd

Cognis Australia Pty Ltd

Dow Chemicals (Australia) Ltd

Du Pont (Australia) Ltd

Fuchs Australia Pty Ltd

HCA Colours Australia P/L

Houghton Australia Pty Ltd

Huntsman Corporation Australia Pty

International Chemicals Ltd

International Sales and Marketing

Lubrication Engineers Pty Ltd

Lubrizol Australia

Nufarm Coogee Pty Ltd

Oilchem Pty Ltd

Orica Australia Pty Ltd

Pennzoil Products Australia Company

Recochem Incorporated

Shoalhaven Mill

Sigma Aldrich Australia Pty Ltd

Swift and Company Limited

APPENDIX 2: List of Associations and Unions Contacted

Associations

AMIRA International Australian Mineral Industries Research Association Limited

Australian Consumer and Specialty Products Association

Australian Mines and Metals Association

Institute of Electrical Inspectors

Minerals Council of Australia

New South Wales Minerals Council Ltd

PACIA – Plastics And Chemicals Industries Association

Waste Contractors & Recyclers Association, NSW

Unions

Australian Council of Trade Unions

Australian Manufacturing Workers Union

Communications Electrical and Plumbing Union - Electrical Division

Construction Forestry Mining Energy Union - Construction and General

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