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# A comparision of regulated chemicals versus emitted PICs and PICs for risk analysis

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## Abstract

In general, toxic combustion byproducts (TCBs) are the unwanted residues remaining in flue gases, combustion ashes, and wastewaters from the operation of an incineration or combustion facility. If a combustor is not well designed and operated, it may emit too high a level of TCBs. Categories of TCBs and some example constituents are as follows:

1. Acid gas: HCl, $NO_x$ and $SO_2$;
2. Organics: Hydrocarbons such as dioxins and furans (PCDDs and PCDFs);
3. Particulates: Trace metals (conventional metals and radioactive metals) and soots;
4. Contaminants in ash; and
5. Contaminants in spent wastewater.

Pollutants in Category (2) above are generally considered to be the products of incomplete combustion (PICs) in the field of hazardous waste incineration.

TCBs has been one of the major technical and sociological issues surrounding the use of incineration as a waste treatment alternative. Because of the complexity and controversy, the U.S. EPA issued a draft "Combustion Strategy" on May 18, 1993. The objective of the "Combustion Strategy" was to address the needs of and to outline the approaches for upgrading the existing incineration standards to better control TCB emissions.

This article lists those chemicals and metals which are regulated by two major U.S. environmental laws, namely, the Clean Air Act Amendments (CAAA) of 1990 and the Resource Conservation and Recovery Act (RCRA) of 1976. The CAAA is to regulate the air emissions from major sources, and the RCRA is to protect human health and the environment from the management of solid wastes, particularly from waste incineration. This paper also lists the PIC chemicals that were studied under U.S. EPA incineration research programs in the 1980s and the

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PIC chemicals that EPA permit writers are considering be the subject of risk analyses during the process of industry's applying for an incinerator operating permit.

## 1. Introduction

The disposal of solid wastes was an environmental issue of the 1980s and it will continue to be as long as waste is generated. Conventional combustion (of coal, oil and gas) has been the subject of research for many decades, however, incineration research for solid waste destruction had been fairly minimal until about the mid-1970s. During the late 1970s to early 1980s, research on solid waste disposal, particularly hazardous waste disposal, was dominated by the RCRA requirements and was very much focused on stationary incineration processes. The incineration activities during that period were later summarized by Oppelt in his article entitled "Incineration of Hazardous Waste — A Critical Review" [1]. In this article, he concluded that EPA's research data and industry's operating experience indicate that incineration, when compared to the other alternative technologies, offers the highest overall degree of destruction and control for the broadest range of waste streams. Compared with other treatment technologies, incineration has the following additional major advantages:

1. *Effectiveness*: It only takes seconds to destroy what landfills may take years to decompose.
2. *Detoxification*: Incineration can routinely achieve 99.99% destruction of any organic, pathogenic, toxic or hazardous substance contained in its feed.
3. *Volume reduction*: The reduction rate is very significant, though it does depend on the ash content of the waste incinerated.
4. *Potential energy recovery*: It has been a general practice for many industries to recover energy from waste incinerators.
5. *No long-term liability*: Once a waste is incinerated, the problem will never re-surface again as it can in a landfill.
6. *Unrecognizable residues*: Rendering waste unrecognizable is one of the major requirements for medical waste treatment.

Although incineration has been proved to be the most effective technology to destroy hazardous waste, it has recently received maximum opposition from the public, compared to alternative technologies. National organizations have been established to campaign against incineration. Local communities often mobilize against it. The core of opposition centers around the unfortunate perception that incineration is simply a "landfill in the sky". This misconception is the result, at least in part, to the lack of knowledge on the subject of toxic combustion byproducts (TCBs), particularly, on the subject of the "Products of Incomplete Combustion", otherwise known as PICs.

The authors, working for the EPA, began to write a series of TCB-related articles in 1988 to search for TCB solutions [2–10]. And, their International Congress on Toxic Combustion Byproducts (ICTCB) was convened in 1989 to provide a forum for scientists to discuss TCB issues. The ICTCB has been held at various major universities every two years since its creation. The Fourth ICTCB was held at the University of California at Berkeley on June 5–7, 1995.

The purpose of this article is to list and compare: (1) chemicals that are regulated by the Clean Air Act Amendments (CAAA) of 1990 and by the Resource Conservation and Recovery Act (RCRA) of 1976; (2) PIC chemicals that were studied under the U.S. EPA full-scale incineration research programs of the 1980s; and (3) PIC chemicals that EPA permit writers are considering be the subject of risk analyses during the process of industry's applying for an incinerator operating permit. The CAAA requires EPA to develop emission standards for the regulated chemicals being emitted from major sources, and the RCRA requires EPA to establish performance standards for the incineration of solid wastes including hazardous waste, municipal waste, medical waste, and mixed waste. [Mixed waste is defined as hazardous waste mixed with radioactive components.]

## 2. RCRA chemicals

### 2.1. Hazardous waste incineration standards

In the United States, RCRA authorized EPA to develop standards to regulate the incineration of hazardous waste. The key elements of the RCRA incineration regulations are the incinerator performance standards which are specified in 40CFR (Code of Federal Regulations), Part 264.343. The owners or operators of incineration facilities must comply with the specified standards in order to receive a RCRA permit to operate. A summary of the current standards is as follows:

(1) An incinerator must achieve a Destruction and Removal Efficiency (DRE) of 99.99% for each Principal Organic Hazardous Constituent (POHC) designated for each waste feed. The 99.99% DRE was primarily derived from the results of a series of incinerator performance tests [11] and from the conclusions drawn from discussions among many national incineration experts.

(2) The DRE for an incinerator/air pollution control system is defined by the following formula:

$$\mathrm{DRE}(\%) = (\mathrm{W_{in}} - \mathrm{W_{out}})/\mathrm{W_{in}} \times 100$$

where:

$W_{in}$ = mass feed rate of POHC fed to the incinerator

$W_{out}$ = mass emission rate of POHC to the atmosphere

(as measured in the stack prior to discharge).

(3) An incinerator burning hazardous waste emitting more than $1.8\,\mathrm{kg\,h^{-1}}$ of HCl must remove 99% of the hydrogen chloride from the exhaust gas.

(4) An incinerator burning hazardous waste must not emit particulate matter exceeding 180 mg/dscm corrected to 7% $0_2$ in the stack gas (unless State regulations require more restrictive emission limits). The correction factor is defined as follows:

$$\text{Correction factor} = 14/(21 - \mathrm{Y})$$

where $Y$ = measured oxygen concentration in the stack gas on a dry basis (expressed as a percentage).

Table 1
Waste type and waste code

| Waste type | Hazardous code | Waste ID code |
|---|---|---|
| Listed hazardous waste | | |
| 1. Waste from nonspecific sources | | F001-F028 |
| 2. Waste from specific sources | | K001-K069 |
| 3. Toxic waste | T | U001-U249 |
| 4. Acute hazardous waste | H | P001-P122 |
| Characteristic hazardous waste | | |
| 1. Ignitable waste | I | D001 |
| 2. Corrosive waste | C | DOO2 |
| 3. Reactive waste | R | DOO3 |
| 4. Extraction procedure (EP) toxicity waste | E | D004-D017 |

(5) A trial burn is required to demonstrate the ability of a hazardous waste incinerator to comply with the above performance standards and to enable operating conditions to be set in the permit to ensure continued compliance.

### 2.2. *Definition of RCRA waste*

RCRA waste (also known herein as hazardous waste) is defined in RCRA, Section 1004. The term "hazardous waste" means any solid waste, or combinations of solid waste, which because of its quantity, concentration, or physical, chemical, or infectious characteristics, may:

(1) Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

(2) Pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

Using the above definition, EPA established four "listed" categories and four "characteristic" categories of hazardous wastes. They and their waste identification (ID) codes are shown in Table 1.

Appendix VIII to Part 261 of 40CFR, which lists specific constituents of concern contained in hazardous waste, was first published in the May 19, 1980 Federal Register. It has been updated semi-annually in 40CFR Part 261 and contains 414 identifiable compounds. Including all possible waste entries such as inorganics, organometallics, PCDDs, PCDFs and N.O.S. (not otherwise specified) compounds, it contains approximately 850 compounds. EPA recommends that Appendix VIII compounds be used for selecting the POHC chemicals to be designated for testing during trial burns.

## 3. CAAA chemicals

Subsequent to the development of the RCRA rules, the U.S. Congress passed the CAAA in 1990. One of the key elements in the Amendments is the control of the 190 hazardous air pollutants (HAPs) from major sources. The HAPs are listed in Title III of the 1990 CAAA (Section 112). A major source is defined as any stationary source or group of stationary sources located within a contiguous area and under common control that emits, or has the potential to emit in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants. The EPA Administrator may establish a lesser quantity, or in the case of radionuclides, establish different criteria for the definition of "major source" than this on the basis of the potency of the air pollutant, persistence, potential for bioaccumulation, other characteristics of the air pollutant, or other relevant factors (Section 112, CAAA).

## 4. List of RCRA and CAAA chemicals

The 414 identifiable Appendix VIII compounds and the 190 HAP compounds are provided in the Table Addendum to this Paper [12,13]. The Table Addendum shows that only 96 compounds belong to both the Appendix VIII list and to the HAP chemicals list. The main reason for generating this listing is to provide a ready-reference so that when specific PICs have to be identified in the future, the compounds which appear on both the HAP and Appendix VIII lists can be used as the first step in the identification process.

## 5. PIC chemicals

Recent researchers, in studies conducted for the EPA, have concluded that PIC formation can result from any of the following hypotheses: (1) PICs are a natural consequence of the thermal degradation of toxic wastes; (2) PIC emission rates are kinetically, not thermodynamically, controlled; and (3) Deviation from normal, average operating conditions are responsible for most PIC emissions [14].

There are two major PIC information sources provided by the EPA. They are: (1) The laboratory/investigative studies of PIC formation by the University of Dayton Research Institute (UDRI) [15]; and (2) The full-scale studies of PICs from hazardous waste combustion by the Midwest Research Institute (MRI) and others [11,16,17]. UDRI's studies focused on the theoretical aspects of PIC formation. UDRI researchers conducted numerous laboratory tests to support their theoretical hypotheses. They also analyzed full-scale PIC data to compare with their laboratory results.

Parallel to UDRI's efforts, MRI's work emphasized the collection and analysis of full-scale incinerator PIC emission data generated from waste incineration and fossil-fuel combustion studies. The studies included 9 boilers co-fired with hazardous waste; 8 hazardous waste incinerators; 6 cement (and other types of) kilns; 2 municipal waste combustors; and 7 fossil fuel boilers (see Table 2).

### *5.1. PICs from combustors*

In the Table Addendum, it can be seen that, of the 53 PICs found in combustor emissions, 33 PIC compounds appear in 40 CFR 261 Appendix VIII (i.e., these PIC

Table 2
Symbols used in the Table addendum and their respective combustors

| | |
|---|---|
| B1 * (site B): | Boiler by Cleaver Brooks, 250 hp, 8,400 lb $hr^{-1}$ of steam, firetube, natural gas |
| B2 (site C): | Boiler by Babcock and Wilcox, 230,000 lb $hr^{-1}$ of steam, multi-burner watertube, natural gas |
| B3 (site D): | Boiler by Babcock and Wilcox, 90,000 lb $hr^{-1}$ of steam, multi-burner watertube, No. 6 oil |
| B4 (site E): | Boiler by Combustion Engineering, 110,000 lb $hr^{-1}$ of steam, single burner, packaged watertube, No. 6 oil and natural gas |
| B5 (site F): | Boiler by Babcock and Wilcox, 60,000 lb $hr^{-1}$ of steam, multi-burner watertube, No. 6 oil |
| B6 (site G): | Boiler by Johnston, 40,000 lb $hr^{-1}$ of steam, multi-burner watertube, natural gas used only for start-up |
| B7 (site I): | Boiler by Foster Wheeler, 62,000 lb $hr^{-1}$ of steam, bent watertube, natural gas |
| B8 (site J): | Boiler by North American, 200 hp, packaged firetube boiler |
| B9 (site K): | Boiler by Combustion Engineering, 60,000 lb $hr^{-1}$ of steam, watertube, No. 6 oil |
| I1: | Incinerator at Trade Waste Incineration, two-chamber liquid injection type and a fixed hearth |
| I2: | Incinerator at DuPont, kiln/afterburner and liquid injection system in parallel |
| I3: | Incinerator at American Cyanamid, liquid injection |
| I4: | Incinerator at Zapata, liquid injection |
| I5: | Incinerator at Upjohn, liquid injection |
| I6: | Incinerator at Mitchell, two chamber liquid injection and hearth |
| I7: | Incinerator at Ross, kiln with secondary chamber |
| I8: | Incinerator at Plant B (a confidential site) |
| K1: | Cement kiln at General Portland Cement, Los Robles, California, 1982 |
| K2: | Cement kiln at General Portland Cement, Los Robles, California, 1984 |
| K3: | Cement kiln at San Juan Cement Company |
| K4: | Light-weight aggregate kiln at Florida Solite Company |
| K5: | Cement kiln at Lone Star Industries |
| K6: | Cement kiln at General Portland Cement, Paulding, Ohio |
| M1: | Resource recovery municipal solid waste (MSW) incinerator |
| M2: | MSW incinerator at Prince Edward Island, Canada |
| P1: | Power Plant No. 1 |
| P2: | Power Plant No. 2 |
| P3: | Power Plant No. 3 |
| P4: | Power Plant No. 4 |
| P5: | Power Plant No. 5 |
| P6: | Power Plant No. 6 |
| P7: | Power Plant No. 7 |

* Symbols of combustors used in the Table Addendum

compounds were found to be emitted during tests on the combustors identified in Table 2) and 20 PIC compounds do not appear in Appendix VIII. The analysis of this PIC information indicated that [16]:

(1)Most PIC compounds were emitted infrequently and at relatively low levels.

(2)Generally, volatile PICs were emitted more frequently and at higher levels than semivolatile PICs.

(3)The emission rates for several volatile PICs, particularly benzene and toluene, were similar for hazardous waste incinerators, and for boilers co-firing wastes, as compared to emission rates for boilers firing only fossil fuels.

(4)Based on the data reviewed, there is no direct correlation between the POHCs tested and PICs emitted.

### 5.2. *PICs for risk assessment*

In Reference numbers [18] and [19], EPA has developed two draft lists of chemicals for potential use in performing risk analysis calculations for a waste incineration facility. The chemicals in the two lists are shown in the Table Addendum of this Paper as "r4" and "r5" under the "Risk PICs" column. The sources for these "boiled down" lists included:

- The hazardous waste constituent list in 40 CFR 261 Appendix VIII (A8);
- The EPA hazardous air pollutants (HAP) list; and
- The EPA/Office of Research and Development list of organic compounds found in

Table 3
HDD/HDF precursor chemical compounds

| CAS No. | Precursor Chemicals | CAAA | RCRA |
|---|---|---|---|
| 108-861 | bromobenzene | | |
| 95-567 | bromophenol(o-) | | |
| 89-645 | chloro-2-nitrophenol(4-) | | |
| 97-507 | chloro-2,4-dimethoxyaniline(5-) | | |
| 350-301 | chloro-4-fluoronitrobenzene(3-) | | |
| 92-046 | chloro-4-phenylphenol(2-) | | |
| 94-746 | chloro-o-toloxy acetic acid(4-) | | |
| 108-907 | chlorobenzene | HAP | A8 |
| 348-516 | chlorofluorobenzene(o-) | | |
| 615-678 | chlorohydroquinone | | |
| 95-578 | chlorophenol(o-) | | |
| 95-885 | chlororesorcinol(4-) | | |
| 827-941 | dibromo-4-nitroaniline(2,6-) | | |
| 89-612 | dichloro-2-nitrobenzene(1,4-) | | |
| 99-309 | dichloro-4-nitroaniline(2,6-) | | |
| 99-547 | dichloro-4-nitrobenzene(1,2-) | | |
| 95-501 | dichlorobenzene(o-) | HAP | A8 |
| 106-467 | dichlorobenzene(p-) | HAP | A8 |
| 94-815 | methyl-4-chlorophenoxy(4-(2-)) butyric acid | | |
| 87-843 | pentabromo-6-chloro-cyclohexane(1,2,3,4,5-) | | |
| 85-223 | pentabromoethylbenzene | | |
| 117-180 | tetrachloro-3-nitrobenzene(1,2,4,5-) | | |
| 95-943 | tetrachlorobenzene(1,2,4,5-) | HAP | A8 |
| 626-391 | tribromobenzene(1,3,5-) | | |
| 87-616 | trichlorobenzene(1,2,3-) | | |
| 120-821 | trichlorobenzene(1,2,4-) | HAP | A8 |
| 108-703 | trichlorobenzene(1,3,5-) | | |
| 89-690 | trichloronitrobenzene(2,4,5-) | | |

combustion devices (includes PICs found in emissions from hazardous waste combustion devices and other combustion devices).

### 5.3. Dioxin and furan

Neither the UDRI nor the MRI study addressed the subject of dioxin and furan emissions. These are, of course, the PIC compounds of most concern for the public at large. Twenty-eight (28) compounds have been listed in 40 CFR Part 766.38 as precursors of the halogenated dibenzodioxins (HDDs) and the halogenated dibenzofurans (HDFs). These 28 compounds are listed in Table 3. The term "precursors" means that the molecular structure of these compounds is conducive to HDD/HDF formation under favorable reaction conditions. In other words, these precursor compounds, when they are burned or incinerated, may produce some dioxins or furans as part of their PICs. As shown in Table 3, only 5 of these 28 precursor compounds appear on both the HAP and Appendix VIII lists (all the others shown there appear on only one or neither of those lists).

## 6. CAAA metals and RCRA metals

The potential emission of volatile metals is another major issue to the public. Information in this area is scarce. In fact, the Table Addendum does not even show the few sites where metals data was gathered during the EPA full-scale testing program. Table 4, however, does provide the list of metals which are regulated under the CAAA or under RCRA. These metals, if they are in incinerator feeds, may produce volatile metals species as combustion byproducts which may be more hazardous than the organic PIC compounds. It is interesting to note that two metals, cobalt and manganese,

Table 4
Metals regulated under CAAA or RCRA

| CAS No. | Metals | CAAA | RCRA |
|---|---|---|---|
| 7440-360 | antimony (Sb) | HAP | A8 |
| 7440-382 | arsenic (As) | HAP | A8 |
| 7440-393 | barium (Ba) | | A8 |
| 7440-417 | beryllium (Be) | HAP | A8 |
| 7440-439 | cadmium (Cd) | HAP | A8 |
| 7440-473 | chromium (Cr) | HAP | A8 |
| 7440-484 | cobalt (Co) | HAP | |
| 7439-921 | lead (Pb) | HAP | A8 |
| 7439-965 | manganese (Mn) | HAP | |
| 7439-976 | mercury (Hg) | HAP | A8 |
| 7440-020 | nickel (Ni) | HAP | A8 |
| 7782-492 | selenium (Se) | HAP | A8 |
| 7440-224 | silver (Ag) | | A8 |
| 7440-280 | thallium (Tl) | | A8 |
| Total Number of Metals | 14 | 11 | 12 |

regulated under the CAAA are not regulated under RCRA. Similarly, three metals, barium, silver, and thallium, regulated under RCRA are not regulated under the CAAA.

## 7. Conclusion

This article has provided information on the chemicals and metals which are regulated under the CAAA of 1990 and the RCRA of 1976. It also has presented information on those PIC chemicals (those products of incomplete combustion) which were detected in emissions from full-scale hazardous waste-burning incinerators, boilers and cement kilns during EPA's research testing program conducted in the 1980s. It also has listed those PIC chemicals which EPA/RCRA permit writers are considering be the subject of risk assessment calculations during the process of evaluating whether to grant an operating permit for an incinerator or other type of thermal destruction device.

## Appendix A. Table Addendum — PICs for risk studies vs. measured PICs and RCRA compounds vs. CAAA compounds

| CAS No. | Chemical compounds | Risk PICs [1] | RCRA | CAAA | Measured (A) PICs |
|---|---|---|---|---|---|
| 75-070 | acetaldehyde | r4 | | HAP | |
| 60-355 | acetamide | | | HAP | |
| 75-058 | acetonitrile ($C_2H_3N$) | | A8 | HAP | |
| 98-862 | acetophenone ($C_8H_8O$) | r4 | A8 | HAP | |
| 75-365 | acetyl chloride ($C_2H_3ClO$) | | A8 | | |
| 591-082 | acetyl-2-thiourea(1-) | | A8 | | |
| 53-963 | acetylaminofluorene(2-) | | A8 | HAP | |
| 107-028 | acrolein ($C_3H_4O$) | r4 | A8 | HAP | |
| 79-061 | acrylamide ($C_3H_5NO$) | | A8 | HAP | |
| 79-107 | acrylic acid | | | HAP | |
| 107-131 | acrylonitrile ($C_3H_3N$) | r4 | A8 | HAP | |
| 1402-682 | aflatoxins | | A8 | | |
| 116-063 | aldicarb ($C_7H_{14}N_2O_2S$) | | A8 | | |
| 309-002 | aldrin ($C_{12}H_8Cl_6$) | | A8 | | |
| 107-186 | allyl alcohol ($C_3H_6O$) | | A8 | | |
| 107-051 | allyl chloride ($C_3H_5Cl$) | | A8 | HAP | |
| 20859-738 | aluminum phosphide | | A8 | | |
| 92-671 | aminobiphenyl(4-) | | A8 | HAP | |
| 2763-964 | aminomethyl-3-isoxazolol(5-) | | A8 | | |
| 504-245 | aminopyridine(4-) | | A8 | | |
| 61-825 | amitrole ($C_2H_4N_4$) | | A8 | | |

[1] See legend at the end of the Table

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| | ammonia | r5 | | | | |
| 7803-556 | ammonium vanadate ($NH_4VO_3$) | | A8 | | | |
| 62-533 | aniline ($C_6H_7N$) | r5 | A8 | HAP | | |
| 90-040 | anisidine(o-) | r5 | | HAP | | |
| 120-127 | anthracene | r4 | | | | |
| 7440-360 | antimony (Sb) | r4 | A8 | | | |
| | antimony compounds | | | HAP | | |
| | antimony compounds, N.O.S. | | A8 | | | |
| 140-578 | aramite ($C_{15}H_{23}ClO_4S$) | | A8 | | | |
| 7440-382 | arsenic (As) | r4 | A8 | | | |
| 7778-394 | arsenic acid ($AsH_30_4$) | | A8 | | | |
| | arsenic compounds (inorganic including arsine) | | | HAP | | |
| | arsenic compounds, N.O.S. | | A8 | | | |
| 1303-282 | arsenic pentoxide ($As_20_5$) | | A8 | | | |
| 1327-533 | arsenic trioxide ($As_20_3$) | | A8 | | | |
| 1332-214 | asbestos | | | HAP | | |
| 492-808 | auramine | | A8 | | | |
| 115-026 | azaserine ($C_5H_7N_3O_4$) | | A8 | | | |
| 103-333 | azobenzene | r5 | | | | |
| 7440-393 | barium (Ba) | r4 | A8 | | | |
| | barium compounds, N.O.S. | | A8 | | | |
| 542-621 | barium cyanide ($C_2BaN_2$) | | A8 | | | |
| 98-873 | benzal chloride ($C_7H_6Cl_2$) | | A8 | | | |
| 100-527 | benzaldehyde | r4 | | | | |
| 71-432 | benzene ($C_6H_6$) | r4 | A8 | | B2-B6; B8; I1-I8; K1-K6 | v |
| 71-432 | benzene (including benzene from gasoline) | | | HAP | | |
| 98-055 | benzenearsonic acid ($C_6H_7AsO_3$) | | A8 | | | |
| 92-875 | benzidine ($C_{12}H_{12}N_2$) | | A8 | HAP | | |
| 106-514 | benzoquinone(p-) | | A8 | | | |
| 96-077 | benzotrichloride | r4 | | | | |
| 98-077 | benzotrichloride ($C_7H_5Cl_3$) | | A8 | HAP | | |
| 50-328 | benzo[a]pyrene ($C_{20}H_{12}$) | r4 | A8 | | | |
| 205-992 | benzo[b]fluoranthene | r4 | A8 | | | |
| | benzo[e]pyrene | r4 | | | | |
| | benzo[g,h]perylene | r4 | | | | |
| 205-823 | benzo[j]fluoranthene | r4 | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 207-089 | benzo[k]fluoranthene | r4 | A8 | | | |
| 100-447 | benzyl chloride | r4 | | | | |
| 100-447 | benzyl chloride ($C_7H_7Cl$) | | A8 | HAP | | |
| 56-553 | benz[a]anthracene (benzo[a]anthracene) | r4 | A8 | | B3 | sv |
| 225-514 | benz[c]acridine | | A8 | | | |
| 7440-417 | beryllium (Be) | r4 | A8 | | | |
| | beryllium compounds | | | HAP | | |
| | beryllium compounds, N.O.S. | | A8 | | | |
| 92-524 | biphenyl | r4 | | HAP | | |
| 111-911 | bis(2-chloroethoxy)methane | r4 | | | | |
| 111-444 | bis(2-chloroethyl)ether | | | | B3; B4 | v |
| 39638-329 | bis(2-chloroisopropyl)ether | | | | B5; B6 | sv |
| 117-817 | bis(2-ethylhexyl)phthalate (BEHP) | r4 | | HAP | B2-B6; I1; I5; I6; M1; M2; P1-P7 | sv |
| 542-881 | bis(chloromethyl)ether | r5 | | HAP | | |
| 598-312 | bromoacetone ($C_3H_5BrO$) | | A8 | | | |
| 74-975 | bromochloromethane | r4 | | | I1; I5 | v |
| 75-274 | bromodichloromethane | r4 | | | I1; I2; I5; I7; B5 | v |
| 590-602 | bromoethane | r4 | | | | |
| 75-252 | bromoform ($CHBr_4$) | r4 | A8 | HAP | B5; I1; I2; I5 | v |
| 74-839 | bromomethane | r4 | | | I5; B5; B6 | v |
| 101-553 | bromophenyl phenyl ether(4-) | | A8 | | | |
| 357-573 | brucine ($C_{23}H_{26}N_2O_4$) | | A8 | | | |
| 106-990 | butadiene(1,3-) | r4 | | HAP | | |
| 85-687 | butyl benzyl phthalate | | A8 | | B6; I6; I8; M1; P1-P4 | sv |
| 85-667 | butylbenzyl phthalate | r4 | | | | |
| 75-605 | cacodylic acid ($C_2H_7AsO_2$) | | A8 | | | |
| 7440-439 | cadmium (Cd) | r4 | A8 | | | |
| | cadmium compounds | | | HAP | | |
| | cadmium compounds, N.O.S. | | A8 | | | |
| 13765-190 | calcium chromate ($CaCrO_4$) | | A8 | | | |
| 156-627 | calcium cyanamide | | | HAP | | |
| 592-018 | calcium cyanide ($Ca(CN)_2$) | | A8 | | | |
| 105-602 | caprolactam | | | HAP | | |
| 133-062 | captan | | | HAP | | |
| 63-252 | carbaryl | | | HAP | | |
| 75-150 | carbon disulfide | r5 | A8 | HAP | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 353-504 | carbon oxyfluoride ($COF_2$) | | A8 | | | |
| 56-235 | carbon tetrachloride ($CCl_4$) | r4 | A8 | HAP | B3-B6; B8; I1-I7; K2; K3 | v |
| 463-581 | carbonyl sulfide | | | HAP | | |
| 120-809 | catechol | | | HAP | | |
| 75-876 | chloral | | A8 | | | |
| 133-904 | chloramben | | | HAP | | |
| 305-033 | chlorambucil ($C_{14}H_{19}Cl_2NO_2$) | | A8 | | | |
| 57-749 | chlordane (alpha and gamma isomers) | | A8 | | | |
| 57-749 | chlordane ($C_{10}H_6Cl_8$) | r4 | A8 | HAP | | |
| | chlorinated benzenes, mono-, di-, tri-, tetra-, and penta- | | A8 | | | |
| | chlorinated ethane, N.O.S. | | A8 | | | |
| | chlorinated fluorocarbons, N.O.S. | | A8 | | | |
| | chlorinated naphthalene, N.O.S. | | A8 | | | |
| | chlorinated phenol, N.O.S. | | A8 | | | |
| 7782-505 | chlorine | | | HAP | | |
| 494-031 | chlornaphazin ($C_{14}H_{15}Cl_2N$) | | A8 | | | |
| 59-507 | chloro-m-cresol(p-) | | A8 | | | sv |
| 107-200 | chloroacetaldehyde ($C_2H_3ClO$) | | A8 | | | |
| 79-118 | chloroacetic acid | | | HAP | | |
| 532-274 | chloroacetophenone(2-) | r4 | | HAP | | |
| | chloroalkyl ethers, N.O.S. | | A8 | | | |
| 106-478 | chloroaniline(p-) | r4 | A8 | | | sv |
| 108-907 | chlorobenzene | r4 | A8 | HAP | B4-B6; B8; I1-I4; I5-I7; K2 | v |
| 510-156 | chlorobenzilate ($C_{16}H_{14}Cl_2O_3$) chlorocyclopentadiene | r4 | A8 | HAP | | sv |
| 110-758 | chloroethyl vinyl ether(2-) | | A8 | | | v |
| 67-663 | chloroform ($CHCl_3$) | r4 | A8 | HAP | B3-B6; I1-I8; K3; K6 | v |
| 74-873 | chloromethane | r4 | | | B6 | v |
| 107-302 | chloromethyl methyl ether | | A8 | HAP | | |
| 91-587 | chloronaphthalene(beta-) | r4 | A8 | | | |
| 95-578 | chlorophenol(2-) | r4 | A8 | | | sv |
| 2039-874 | chlorophenol(o-) | | | | B3; I5 | sv |
| 5344-821 | chlorophenylthiourea(1-(o-)) | | A8 | | | |
| 126-998 | chloroprene | | A8 | HAP | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 75-296 | chloropropane(2-) | r4 | | | | |
| 542-767 | chloropropionitrile(3-) | | A8 | | | sv |
| 7440-473 | chromium (Cr) | r4 | A8 | | | |
| | chromium compounds | | | HAP | | |
| | chromium compounds, N.O.S. | | A8 | | | |
| 218-019 | chrysene ($C_{18}H_{12}$) | r4 | A8 | | | |
| 6358-538 | citrus red No. 2 | | A8 | | | |
| 8007-452 | coal tar creosote | | A8 | | | |
| | cobalt compounds | | | HAP | | |
| | coke oven emissions | | | HAP | | |
| 544-923 | copper cyanide (CuCN) | | A8 | | | |
| 8001-589 | creosote | | A8 | | | |
| 1319-773 | cresol ($C_7H_8O$) | | A8 | | | |
| 108-394 | cresol(m-) | r4 | | HAP | | |
| 95-487 | cresol(o-) | r4 | | HAP | | |
| 106-445 | cresol(p-) | r4 | | HAP | | |
| 1319-773 | cresols/cresylic acid (isomers and mixture) | | | HAP | | |
| 4170-303 | crotonaldehyde | r4 | A8 | | | |
| 98-828 | cumene | r5 | | HAP | | |
| | cyanide compounds | | | HAP | | |
| | cyanides (soluble salts and complexes), N.O.S. | | A8 | | | |
| 460-195 | cyanogen ($C_2N_2$) | r5 | A8 | | | |
| 506-683 | cyanogen bromide (CNBr) | r5 | A8 | | | |
| 506-774 | cyanogen chloride (CNCl) | r5 | A8 | | | |
| 14901-087 | cycasin ($C_8H_{16}N_2O_7$) | | A8 | | | |
| 131-895 | cyclohexyl-4,6-dinitro-phenol(2-) | r5 | A8 | | | |
| 50-180 | cyclophosphamide ($C_7H_{15}Cl_2N_2O_2P$) | | A8 | | | |
| 94-757 | D(2,4-) | r4 | A8 | | | |
| 94-757 | D(2,4-) salts and esters | | A8 | HAP | | |
| 20830-813 | daunomycin | | A8 | | | |
| 72-548 | DDD (dichlorodiphenyl-dichloroethane) | | A8 | | | |
| 3547-044 | DDE | r4 | | HAP | | |
| 72-559 | DDE (dichlorodiphenyl-dichloroethylene) | | A8 | | | |
| 50-293 | DDT (dichlorodiphenyl-trichloroethane) | | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 117-840 | di-n-octylphthalate | r4 | | | B4; P1; P3; P5 | sv |
| | di-n-propylnitrosamine | r5 | | | | |
| 2303-164 | diallate ($C_{10}H_{17}Cl_2NOS$) | | A8 | | | |
| 334-883 | diazomethane | | | HAP | | |
| 132-649 | dibenzofurans | | | HAP | | |
| | dibenzo[a,e]fluoranthene | r5 | | | | |
| 192-654 | dibenzo[a,e]pyrene | | A8 | | | |
| | dibenzo[a,h]fluoranthene | r5 | | | | |
| 189-640 | dibenzo[a,h]pyrene | | A8 | | | |
| 189-559 | dibenzo[a,i]pyrene | | A8 | | | |
| 194-592 | dibenzo[c,g]carbazole(7h-) | | A8 | | | |
| 226-368 | dibenz[a,h]acridine | | A8 | | | |
| 53-703 | dibenz[a,h]anthracene ($C_{22}H_{14}$) | r4 | A8 | | | |
| 224-420 | dibenz[a,j]acridine | | A8 | | | |
| 96-128 | dibromo-3-chloro-propane(1,2-) | r4 | A8 | HAP | | v |
| 84-742 | dibutyl phthalate | r4 | A8 | HAP | B2-B6; M1; P1-P4 | sv |
| 764-410 | dichloro-2-butene(1,4-) | | A8 | | | |
| 764-410 | dichloro-2-butene(cis-1,4-) | r4 | | | I2 | v |
| 764-410 | dichloro-2-butene(trans-1,4-) | r4 | | | | |
| 25321-226 | dichlorobenzene, N.O.S. | | A8 | | | |
| 95-501 | dichlorobenzene(1,2-) | r4 | | | | |
| 95-501 | dichlorobenzene(1,3-) | r4 | | | | |
| 106-467 | dichlorobenzene(1,4-) | r4 | | | | |
| 541-731 | dichlorobenzene(m-) | | A8 | | B3; I5; I8 | sv |
| 95-501 | dichlorobenzene(o-) | | A8 | | I5; I8 | sv |
| 106-467 | dichlorobenzene(p-) | | A8 | HAP | B3; I5; I8 | sv |
| 91-941 | dichlorobenzidine(3,3'-) | r5 | A8 | HAP | | sv |
| 75-718 | dichlorodifluoromethane (CFC-12) | r4 | A8 | | | v |
| 75-343 | dichloroethane(1,1-) | | | | B3; B6 | v |
| 107-062 | dichloroethane(1,2-) | | | | B3; B5; B6 | v |
| 107-062 | dichloroethane(1,2-) | r4 | | | | |
| 111-444 | dichloroethyl ether ($C_4H_8Cl_2O$) | | A8 | HAP | | |
| 25323-302 | dichloroethylene, N.O.S. | | A8 | | | |
| 75-354 | dichloroethylene(1,1-) ($C_2H_2Cl_2$) | r4 | A8 | | B3; B4; B5; B6 | v |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 540-590 | dichloroethylene(1,2-) | | | | B4; B5 | v |
| 156-605 | dichloroethylene(trans-1,2-) | r4 | A8 | | | v |
| 108-601 | dichloroisopropyl ether | r5 | A8 | | | |
| 111-911 | dichloromethoxy ethane | | A8 | | | |
| 542-881 | dichloromethyl ether | r5 | A8 | | | |
| | dichloropentadiene | r5 | | | | |
| 120-832 | dichlorophenol(2,4-) | r4 | A8 | | B3 | sv |
| 87-650 | dichlorophenol(2,6-) | | A8 | | | sv |
| 696-286 | dichlorophenylarsine | | A8 | | | |
| 26638-197 | dichloropropane, N.O.S. | | A8 | | | |
| 542-756 | dichloropropane(1,3-) | | A8 | HAP | | |
| 26545-733 | dichloropropanol ($C_3H_6ClO$) N.O.S. | | A8 | | | |
| | dichloropropene, N.O.S. | | A8 | | | |
| 542-756 | dichloropropene(cis-1,3-) | r4 | | | | |
| 542-756 | dichloropropene(trans-1,3-) | r4 | | | | |
| 542-756 | dichloropropylene | | | | B5 | v |
| 62-737 | dichlorvos | | | HAP | | |
| 60-571 | dieldrin ($C_{12}H_8Cl_6O$) | | A8 | | | |
| 1464-535 | diepoxybutane(1,2:3,4-) | | A8 | | | |
| 111-422 | diethanolamine | | | HAP | | |
| 84-662 | diethyl phthalate | r4 | A8 | | B3-B5; I5; I8; M1; P1-P4 | sv |
| 64-675 | diethyl sulfate | | | HAP | | |
| 121-697 | diethyl(n,n-) aniline | | | HAP | | |
| 297-972 | diethyl-o-pyrazinyl phosphorothioate(o,o-) | | A8 | | | |
| 311-455 | diethyl-p-nitrophenyl phospate | | A8 | | | |
| 3288-582 | diethyl-s-methyl dithiophosphate(o,o-) | | A8 | | | |
| 692-422 | diethylarsine | | A8 | | | |
| 123-911 | diethylenedioxide(1,4-) | | A8 | | | |
| 117-817 | diethylhexyl phthalate | | A8 | | | |
| 1615-801 | diethylhydrazine(n,n'-) | | A8 | | | |
| 56-531 | diethylstilbesterol | | A8 | | | |
| 94-586 | dihydrosafrole | | A8 | | | |
| 55-914 | diisopropyl fluorophosphate (DFP) | | A8 | | | |
| 60-515 | dimethoate ($C_5H_{12}NO_3PS_2$) | | A8 | | | |
| 119-904 | dimethoxybenzidine(3,3'-) | r4 | A8 | HAP | | |
| 60-117 | dimethyl aminoazobenzene | r5 | | HAP | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 119-937 | dimethyl benzidine(3,3'-) | | A8 | HAP | | |
| 79-447 | dimethyl carbamoyl chloride | | A8 | HAP | | |
| 68-122 | dimethyl formamide | | | HAP | | |
| 57-147 | dimethyl hydrazine(1,1-) ($C_2H_8N_2$) | | A8 | HAP | | |
| 131-113 | dimethyl phthalate ($C_{10}H_{10}O_4$) | r4 | A8 | HAP | B6; I8; P1; P7 | sv |
| 77-781 | dimethyl sulfate ($C_2H_6O_4S$) | r5 | A8 | HAP | | |
| 60-117 | dimethylaminoazobenzene(p-) | | A8 | | | |
| 57-976 | dimethylbenz[a]anthracene(7,12-) | | A8 | | | |
| 540-738 | dimethylhydrazine(1,2-) | r5 | A8 | | | |
| | dimethylnitrosamine | r5 | | | | |
| 122-098 | dimethylphenethylamine-(alpha,alpha-) | | A8 | | | |
| 105-679 | dimethylphenol(2,4-) | r4 | A8 | | B5; B6; I6; I7 | sv |
| 534-521 | dinitro-o-cresol(4,6-) ($C_7H_6N_2O_5$) | r5 | A8 | | | |
| 534-521 | dinitro-o-cresol(4,6-) and salts | | A8 | HAP | | |
| 25154-545 | dinitrobenzene, N.O.S. | | A8 | | | |
| 99-650 | dinitrobenzene(1,3-) | r4 | | | | |
| | dinitrobenzene(o-) | r4 | | | | |
| 100-294 | dinitrobenzene(p-) | r4 | | | | |
| 51-285 | dinitrophenol(2,4-) | r5 | A8 | HAP | | |
| 121-142 | dinitrotoluene(2,4-) | r4 | A8 | HAP | | |
| 606-202 | dinitrotoluene(2,6-) | r4 | A8 | | | |
| 88-857 | dinoseb ($C_{10}H_{12}N_2O_5$) | | A8 | | | |
| 123-911 | dioxane(1,4-) | r4 | | HAP | | |
| 122-394 | diphenylamine | r5 | A8 | | | |
| 122-667 | diphenylhydrazine(1,2-) | r5 | A8 | HAP | | |
| 298-044 | disulfoton (disyston) ($C_8H_{19}O_2PS_3$) | | A8 | | | |
| 541-537 | dithiobiuret | | A8 | | | |
| 115-297 | endosulfan ($C_9H_6Cl_6O_3S$) | | A8 | | | |
| 145-733 | endothall ($C_8H_{10}O_5$) | r5 | A8 | | | |
| 72-208 | endrin ($C_{12}H_8Cl_6O$) | | A8 | | | |
| | endrin and metabolites | | A8 | | | |
| 106-898 | epichlorohydrin | r5 | A8 | HAP | | |
| 51-434 | epinephrine ($C_9H_{13}NO_3$) | | A8 | | | |
| 106-887 | epoxybutane(1,2-) | | | HAP | | |
| | ethoxyethanol | r5 | | | | |
| 140-885 | ethyl acrylate | | | HAP | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 100-414 | ethyl benzene | | | HAP | | |
| 51-796 | ethyl carbamate ($C_3H_7NO_2$) | r5 | A8 | HAP | | |
| 75-003 | ethyl chloride | r5 | | HAP | | |
| 107-120 | ethyl cyanide | | A8 | | | |
| 97-632 | ethyl methacrylate | r5 | A8 | | | |
| 62-500 | ethyl methanesulfonate ($C_3H_8O_3S$) | r5 | A8 | | | |
| 100-414 | ethylbenzene | r4 | | | | |
| 106-934 | ethylene dibromide (EDB) | r4 | A8 | HAP | | |
| 107-062 | ethylene dichloride | | A8 | HAP | | |
| 107-211 | ethylene glycol | r5 | | HAP | | |
| 111-762 | ethylene glycol monobutyl ether | r5 | | | | |
| | ethylene glycol monoethyl ether | r5 | | | | |
| 110-805 | ethylene glycol monoethyl ether | r5 | A8 | | | |
| 75-218 | ethylene oxide | r4 | A8 | HAP | | |
| 96-457 | ethylene thiourea | r4 | A8 | HAP | | |
| 111-546 | ethylenebisdithio-carbamic acid | | A8 | | | |
| 111-546 | ethylenebisdithio-carbamic acid salts & esters | | A8 | | | |
| 151-564 | ethyleneimine ($C_2H_5N$) | | A8 | HAP | | |
| 75-343 | ethylidene dichloride | r4 | A8 | HAP | | |
| 52-857 | famphur ($C_{10}H_{16}NO_5PS_2$) | | A8 | | | |
| | fine mineral fibers | | | HAP | | |
| 206-440 | fluoranthene | r4 | A8 | | B2; B4; I7; M1; M2; P1 | sv |
| 7782-414 | fluorine | | A8 | | | |
| 640-197 | fluoroacetamide | | A8 | | | |
| 62-748 | fluoroacetic acid, sodium salt | | A8 | | | |
| 50-000 | formaldehyde ($CH_2O$) | r4 | A8 | HAP | | |
| 64-186 | formic acid ($CH_2O_2$) | r5 | A8 | | | |
| | furfural | r5 | | | | |
| 765-344 | glycidylaldehyde | r5 | A8 | | | |
| | glycol ethers | | | HAP | | |
| | halomethanes, N.O.S. | | A8 | | | |
| 76-448 | heptachlor ($C_{10}H_5Cl_7$) | r4 | A8 | HAP | | |
| 1024-573 | heptachlor epoxide | | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| | heptachlor epoxide (alpha, beta, and gammer isomers) | | A8 | | | |
| | heptachlorodibenzo-p-dioxins | | A8 | | | |
| | heptachlorodibenzo-p-dioxin-(1,2,3,4,6,7,8) | r4 | | | | |
| | heptachlorodibenzofuran-(1,2,3,4,7,8,9) | r4 | | | | |
| | heptachlorodibenzofuran-(1,2,3,4,6,7,8) | r4 | | | | |
| | heptachlorodibenzofurans | | A8 | | | |
| 118-741 | hexachlorobenzene | r4 | A8 | HAP | B6; I5; I8 | sv |
| 87-683 | hexachlorobutadiene | r4 | A8 | HAP | | sv |
| | hexachlorocyclohexane-(gammar) | r4 | | | | |
| 319-846 | hexachlorocyclohexane(alpha) | r4 | | | | |
| 319-857 | hexachlorocyclohexane(beta) | r4 | | | | |
| 77-474 | hexachlorocyclopentadiene | r4 | A8 | HAP | | sv |
| | hexachlorodibenzo-p-dioxins | | A8 | | | |
| | hexachlorodibenzo-p-dioxin-(1,2,3,6,7,8) | r4 | | | | |
| | hexachlorodibenzo-p-dioxin-(1,2,3,4,7,8) | r4 | | | | |
| | hexachlorodibenzo-p-dioxin-(1,2,3,7,8,9) | r4 | | | | |
| | hexachlorodibenzofuran-(1,2,3,7,8,9) | r4 | | | | |
| | hexachlorodibenzofuran-(2,3,4,6,7,8) | r4 | | | | |
| | hexachlorodibenzofurans | | A8 | | | |
| | hexachlorodibenzofuran-(1,2,3,4,7,8) | r4 | | | | |
| | hexachlorodibenzofuran-(1,2,3,6,7,8) | r4 | | | | |
| 67-721 | hexachloroethane | r4 | A8 | HAP | | sv |
| 70-304 | hexachlorophene | r4 | A8 | | | |
| 1888-717 | hexachloropropene | | A8 | | | sv |
| 757-584 | hexaethyl tetraphosphate | | A8 | | | |
| 822-060 | hexamethylene-1,6-diisocyanate | r5 | | HAP | | |
| 680-319 | hexamethylphosphoramide | | | HAP | | |
| 110-543 | hexane (n-hexane) | r4 | | HAP | | |
| 302-012 | hydrazine ($H_4N_2$) | | A8 | HAP | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 7647-010 | hydrochloric acid | | | HAP | | |
| 74-908 | hydrogen cyanide (HCN) | | A8 | | | |
| 7664-393 | hydrogen fluoride (HF) | | A8 | HAP | | |
| 7783-064 | hydrogen sulfide ($H_2S$) | | A8 | HAP | | |
| 123-319 | hydroquinone | | | HAP | | |
| 193-395 | indeno[1,2,3-cd]pyrene | r4 | A8 | | | |
| 78-831 | isobutyl alcohol ($C_4H_{10}O$) | | A8 | | | |
| 465-736 | isodrin | | A8 | | | |
| 78-591 | isophorone | | | HAP | | |
| 120-581 | isosafrole ($C_{10}H_{10}O_2$) | | A8 | | | |
| 143-500 | kepone | | A8 | | | |
| 303-344 | lasiocarpine ($C_{21}H_{33}NO_7$) | | A8 | | | |
| 7439-921 | lead (Pb) | r4 | A8 | | | |
| 301-042 | lead acetate ($C_4H_6O_4Pb$) | | A8 | | | |
| | lead compounds | | | HAP | | |
| | lead compounds, N.O.S. | | A8 | | | |
| 7446-277 | lead phosphate ($Pb_3(PO_4)_2$) | | A8 | | | |
| 1335-326 | lead subacetate | | A8 | | | |
| 58-899 | lindane | | A8 | | | |
| 58-899 | lindane (all isomers) | | | HAP | | |
| 108-316 | maleic anhydride ($C_4H_2O_3$) | | A8 | HAP | | |
| 123-331 | maleic hydrazide ($C_2H_4N_2O_2$) | r4 | A8 | | | |
| 109-773 | malononitrile ($C_3H_2N_2$) | r5 | A8 | | | |
| | manganese compounds | | | HAP | | |
| 148-823 | melphalan ($C_{13}H_{18}Cl_2N_2O_2$) | | A8 | | | |
| 7439-976 | mercury | r4 | A8 | | | |
| | mercury compounds | | | HAP | | |
| | mercury compounds, N.O.S. | | A8 | | | |
| 628-864 | mercury fulminate | | A8 | | | |
| | methacrylonitrile | r5 | | | | |
| 126-987 | methacrylonitrile ($C_4H_5N$) | | A8 | | | |
| 67-561 | methanol | | | HAP | | |
| 91-805 | methapyrilene ($C_{14}H_{19}N_3S$) | | A8 | | | |
| 16752-775 | methomyl ($C_5H_{10}N_2O_2S$) | | A8 | | | |
| 72-435 | methoxychlor ($C_{16}H_{15}Cl_3O_2$) | r4 | A8 | HAP | | |
| | methoxyethanol(2-) | r5 | | | | |
| 74-839 | methyl bromide ($CH_3Br$) | | A8 | HAP | | |
| 74-873 | methyl chloride ($CH_3Cl$) | | A8 | HAP | | |
| 79-221 | methyl chlorocarbonate | | A8 | | | |
| 71-556 | methyl chloroform ($C_2H_3Cl_3$) | r4 | A8 | HAP | | |
| 1338-234 | methyl ethyl ketone peroxide | | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 78-933 | methyl ethyl ketone (MEK) | r4 | A8 | HAP | I5; I6; I7; K4; K5; K6 | v |
| 60-344 | methyl hydrazine | | A8 | HAP | | |
| 74-884 | methyl iodide | | A8 | HAP | | |
| 108-101 | methyl isobutyl ketone | r5 | | HAP | | |
| 624-839 | methyl isocyanate | r5 | A8 | HAP | | |
| | methyl mercury | r5 | | | | |
| 80-626 | methyl methacrylate | | A8 | HAP | B4 | v |
| 66-273 | methyl methanesulfonate | | A8 | | | |
| 298-000 | methyl parathion | | A8 | | | |
| | methyl styrene (mixed isomers) | r5 | | | | |
| 1634-044 | methyl tert butyl ether | r5 | | HAP | | |
| 56-495 | methylcholanthrene(3-) | | A8 | | | |
| 106-872 | methylcyclohexane | r4 | | | | |
| 101-144 | methylene bis(2-chloroaniline)-(4,4'-) | | A8 | HAP | | |
| 74-953 | methylene bromide ($CH_2Br_2$) | r4 | A8 | | I1; I5 | v |
| 75-092 | methylene chloride ($CH_2Cl_2$) | r4 | A8 | HAP | B2; B4; B5; B6; I1-I7; K1-K3; K5; K6 | v |
| 101-688 | methylene diphenyl diisocyanate | | | HAP | | |
| 101-779 | methylenedianiline(4,4'-) | r5 | | HAP | | |
| 75-865 | methyllactonitrile(2-) | | A8 | | | |
| 56-042 | methylthiouracil | | A8 | | | |
| 50-077 | mitomycin C ($C_{16}H_{19}N_3O_6$) | | A8 | | | |
| 70-257 | MNNG [methyl-n'-nitro-a-nitrosoguanidine(n-)] | | A8 | | | |
| | mononitrobenzene | | | | I3 | sv |
| 505-602 | mustard gas ($C_4H_8Cl_2S$) | | A8 | | | |
| 91-203 | naphthalene | r4 | A8 | HAP | B3-B6; I1-I3; I5; I6; I8; K5; K6; M1-M2; P1-P7 | sv |
| 130-154 | naphthoquinone(1,4-) | | A8 | | | |
| 134-327 | naphthylamine(alpha-) | | A8 | | | |
| 91-598 | naphthylamine(beta-) | | A8 | | | |
| 86-884 | naphthylthiourea(alpha-) | | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 7440-020 | nickel (Ni) | r4 | A8 | | | |
| 13463-393 | nickel carbonyl ($Ni(CO)_4$) | | A8 | | | |
| | nickel compounds | | | HAP | | |
| | nickel compounds, N.O.S. | | A8 | | | |
| 557-197 | nickel cyanide ($Ni(CN)_2$) | | A8 | | | |
| 54-115 | nicotine ($C_{10}H_{14}N_2$) | | A8 | | | |
| 54-115 | nicotine and salts | | A8 | | | |
| 10102-439 | nitric oxide (NO) | | A8 | | | |
| 99-558 | nitro-o-toluidine(5-) | | A8 | | | |
| 88-744 | nitroaniline(o-) | r4 | | | | |
| 100-016 | nitroaniline(p-) | | A8 | | | |
| 98-953 | nitrobenzene | r4 | A8 | HAP | | |
| 92-933 | nitrobiphenyl(4-) | | | HAP | | |
| 10102-440 | nitrogen dioxide ($NO_2$) | | A8 | | | |
| 51-752 | nitrogen mustard | | A8 | | | |
| 55-867 | nitrogen mustard, hydrochloride salt | | A8 | | | |
| 126-852 | nitrogen mustard n-oxide | | A8 | | | |
| 302-705 | nitrogen mustard, n-oxide, hydrochloride salt | | A8 | | | |
| 55-630 | nitroglycerine ($C_3H_5N_3O_9$) | | A8 | | | |
| 100-027 | nitrophenol(4-) | r4 | | HAP | | |
| 100-027 | nitrophenol(p-) | | A8 | | | |
| 79-469 | nitropropane(2-) ($C_3H_7NO_2$) | | A8 | HAP | | |
| 35576-911 | nitrosamines, N.O.S. | | A8 | | | |
| 759-739 | nitroso-n-ethylurea(n-) | | A8 | | | |
| 615-532 | nitroso-n-methylurethane(n-) | | A8 | | | |
| 684-935 | nitroso-n-methylurea(n-) | | | HAP | | |
| 684-935 | nitroso-n-methylurea(n-) | | A8 | | | |
| 924-163 | nitrosodi-n-butylamine(n-) | r4 | A8 | | | |
| 1116-547 | nitrosodiethanolamine(n-) | | A8 | | | |
| 55-185 | nitrosodiethylamine(n-) | | A8 | | | |
| 62-759 | nitrosodimethylamine(n-) | | A8 | HAP | | |
| 10595-956 | nitrosomethylethylamine(n-) | | A8 | | | |
| 4549-400 | nitrosomethylvinylamine(n-) | | A8 | | | |
| 59-892 | nitrosomorpholine(n-) | | A8 | HAP | | |
| 16543-558 | nitrosonornicotine(n-) | | A8 | | | |
| 100-754 | nitrosopiperidine(n-) | | A8 | | | |
| 930-552 | nitrosopyrrolidine(n-) | | A8 | | | |
| 13256-229 | nitrososarcosine(n-) | | A8 | | | |
| | octachlorodibenzo-p-dioxin | r4 | | | | |
| | octachlorodibenzofuran | r4 | | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 152-169 | octamethylpyro-phosphoramide | | A8 | | | |
| 20816-120 | osmium tetroxide | | A8 | | | |
| 123-637 | paraldehyde ($C_6H_{12}O_3$) | | A8 | | | |
| 56-382 | parathion ($C_{10}H_{14}NO_5PS$) | | A8 | HAP | | |
| 608-935 | pentachlorobenzene | r4 | A8 | | | sv |
| | pentachlorobenzofurans | | A8 | | | |
| | pentachlorodibenzo-p-dioxins | | A8 | | | |
| | pentachlorodibenzo-p-dioxin-(1,2,3,7,8) | r4 | | | | |
| | pentachlorodibenzofuran-(1,2,3,7,8) | r4 | | | | |
| 76-017 | pentachloroethane | | A8 | | | sv |
| 82-688 | pentachloronitrobenzene (PCNB) | r4 | A8 | HAP | | sv |
| 87-865 | pentachlorophenol | r4 | A8 | HAP | I5 | sv |
| 62-442 | phenacetin | | A8 | | | |
| 108-952 | phenol ($C_6H_6O$) | r4 | A8 | HAP | B2-B6; B9; I2; I6; I8; K3 | sv |
| | phenyl(1-) ethanol | | | | K3 | sv |
| 25265-763 | phenylenediamine | | A8 | | | |
| 106-503 | phenylenediamine(p-) | | | HAP | | |
| 62-384 | phenylmercury acetate | | A8 | | | |
| 103-855 | phenylthiourea | | A8 | | | |
| 298-022 | phorate ($C_7H_{17}O_2PS_3$) | | A8 | | | |
| 75-445 | phosgene ($CCl_2O$) | r4 | A8 | HAP | | |
| 7803-512 | phosphine ($H_3P$) | | A8 | HAP | | |
| 7723-140 | phosphorus | | | HAP | | |
| | phthalate, N.O.S. * | | | | K3; K6 | sv |
| | phthalic acid ester, N.O.S | | A8 | | | |
| 85-449 | phthalic anhydride ($C_8H_4O_3$) | r5 | A8 | HAP | | |
| 109-068 | picoline(2-) ($C_6H_7N$) | | A8 | | | |
| 1336-363 | polychlorinated biphenyls | | | HAP | | |
| 1336-363 | polychlorinated biphenyls (209 congeners) | r4 | | | | |
| | polychlorinated biphenyls (PCBs) (aroclors), N.O.S. | | A8 | | | |
| | polycylic organic matter | | | HAP | | |
| 151-508 | potassium cyanide (KCN) | | A8 | | | |
| 506-616 | potassium silver cyanide ($(KAg(CN)_2)$ | | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 23950-585 | pronamide | r5 | A8 | | | sv |
| 1120-714 | propane sultone(1,3-) | r5 | A8 | HAP | | |
| 107-197 | propargyl alcohol | r5 | A8 | | | |
| 57-578 | propiolactone (beta-) | | | HAP | | |
| 123-386 | propionaldehyde | r4 | | HAP | | |
| 114-261 | propoxur | | | HAP | | |
| 107-108 | propylamine(n-) ($C_3H_9N$) | | A8 | | | |
| 78-875 | propylene dichloride | r4 | A8 | HAP | | |
| 75-569 | propylene oxide | | | HAP | | |
| 75-558 | propylenimine(1,2-) | | A8 | HAP | | |
| 51-525 | propylthiouracil ($C_7H_{10}N_2OS$) | | A8 | | | |
| 12-900 | pyrene | | | | B4; I7; M1; M2; P1 | sv |
| 110-861 | pyridine ($C_5H_5N$) | r5 | A8 | | | |
| 91-225 | quinoline | r4 | | HAP | | |
| 106-514 | quinone | r4 | | HAP | | |
| | radionuclides (including radon) | | | HAP | | |
| 50-555 | reserpine ($C_{33}H_{40}N_2O_9$) | | A8 | | | |
| 108-463 | resorcinol ($C_6H_6O_2$) | | A8 | | | |
| 81-072 | saccharin ($C_7H_5NO_3S$) | | A8 | | | |
| | saccharin salts | | A8 | | | |
| 94-597 | safrole ($C_{10}H_{10}O_2$) | r4 | A8 | | | |
| 7782-492 | selenium (Se) | r4 | A8 | | | |
| | selenium compounds | | | HAP | | |
| 7782-492 | selenium compounds, N.O.S. | | A8 | | | |
| 7446-084 | selenium dioxide ($SeO_2$) | | A8 | | | |
| 7488-564 | selenium sulfide | | A8 | | | |
| | selenourea | | A8 | | | |
| 7440-224 | silver (Ag) | r4 | A8 | | | |
| | silver compounds, N.O.S. | | A8 | | | |
| 506-649 | silver cyanide (Ag(CN)) | | A8 | | | |
| 93-721 | silvex | | A8 | | | |
| 143-339 | sodium cyanide (Na(CN)) | | A8 | | | |
| 18883-664 | streptozotocin ($C_8H_{15}N_3O_7$) | | A8 | | | |
| | strychnine | r5 | | | | |
| 57-249 | strychnine ($C_{21}H_{22}N_2O_2$) | | A8 | | | |
| | strychnine salts | | A8 | | | |
| 100-425 | styrene | r4 | | HAP | | |
| 96-093 | styrene oxide | | | HAP | | |
| 93-765 | T(2,4,5-) (trichlorophenoxy-acetic acid) | | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 95-943 | tetrachlorobenzene(1,2,4,5-) ($C_6H_2Cl_4$) | r4 | A8 | | | sv |
| | tetrachlorodibenzo-p-dioxins | | A8 | | | |
| 1746-016 | tetrachlorodibenzo-p-dioxin (2,3,7,8-) (TCDD) | r4 | A8 | HAP | | |
| | tetrachlorodibenzofuran | | A8 | | | |
| 25322-207 | tetrachloroethane, N.O.S. | | A8 | | | |
| 79-345 | tetrachloroethane(1,1,2,2-) | r4 | A8 | HAP | B5; B6 | v |
| 630-206 | tetrachloroethane(1,1,1,2-) ($C_2H_2Cl_4$) | r4 | A8 | | | v |
| 127-184 | tetrachloroethylene | r4 | A8 | HAP | B3-B6; I1-I5; I7; I8; K1; K4; K6 | v |
| 58-902 | tetrachlorophenol(2,3,4,6-) | r4 | A8 | | | sv |
| 78-002 | tetraethyl lead ($C_8H_{20}Pb$) | | A8 | | | |
| 107-493 | tetraethyl pyrophosphate (TEPP) | | A8 | | | |
| 3689-245 | tetraethyldithiopyro-phosphate | | A8 | | | |
| 509-148 | tetranitromethane | | A8 | | | |
| 1314-325 | thallic oxide | | A8 | | | |
| 7440-280 | thallium (Tl) | r4 | A8 | | | |
| 563-688 | thallium acetate | | A8 | | | |
| 7791-120 | thallium chloride (TlCl) | | A8 | | | |
| | thallium compounds, N.O.S. | | A8 | | | |
| 12039-520 | thallium selenite ($Tl_2Se$) | | A8 | | | |
| 6533-739 | thallium(I) carbonate | | A8 | | | |
| 10102-451 | thallium(I) nitrate ($TlNO_3$) | | A8 | | | |
| 7446-186 | thallium(I) sulfate | | A8 | | | |
| 62-555 | thioacetamide ($C_2H_5NS$) | | A8 | | | |
| 39196-184 | thiofanox | | A8 | | | |
| 74-931 | thiomethanol | | A8 | | | |
| 108-985 | thiophenol ($C_6H_6S$) | | A8 | | | |
| 79-196 | thiosemicarbazide ($CH_5N_3S$) | | A8 | | | |
| 62-566 | thiourea ($CH_4N_2S$) | | A8 | | | |
| 137-268 | thiram | | A8 | | | |
| 7550-450 | titanium tetrachloride | | | HAP | | |
| 108-883 | toluene ($C_7H_8$) | r4 | A8 | HAP | B1-B6; B8; I1-I8; K2; K4; K5; K6 | v |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 95-807 | toluene diamine(2,4-) | | A8 | HAP | | |
| 26471-625 | toluene diisocyanate | | A8 | | | |
| 584-849 | toluene(2,4-) diisocyanate | r5 | | HAP | | |
| 91-087 | toluene(2,6-) diisocyanate | | | | I5 | sv |
| 823-405 | toluene-2,6-diamine | r5 | A8 | | | |
| 496-720 | toluene-3,4-diamine | | A8 | | | |
| 25376-458 | toluenediamine | | A8 | | | |
| 95-534 | toluidine(o-) ($C_7H_9N$) | r4 | A8 | HAP | | |
| 636-215 | toluidine(o-) hydrochloride | | A8 | | | |
| 106-490 | toluidine(p-) ($C_7H_9N$) | r4 | A8 | | | |
| 8001-352 | toxaphene ($C_{10}H_{10}Cl_8$) | | A8 | | | |
| 8001-352 | toxaphene (chlorinated camphene) | | | HAP | | |
| 120-821 | trichlorobenzene(1,2,4-) | r4 | A8 | HAP | I5; I8; K1 | sv |
| 71-556 | trichloroethane(1,1,1-) | | | | I3-I6; B3-B6; K1; K2; K5; K6 | v |
| 79-005 | trichloroethane(1,1,2-) | r4 | A8 | HAP | B3; B4 | v |
| 79-016 | trichloroethylene ($C_2HCl_3$) | r4 | A8 | HAP | B2-B5; B8; I1-I8; K1; K2 | v |
| 75-707 | trichloromethanithiol | | A8 | | | |
| 75-694 | trichloromonofluoromethane ($CCl_3F$) | r4 | A8 | | | v |
| 95-954 | trichlorophenol(2,4,5-) ($C_6H_3Cl_3O$) | r4 | A8 | HAP | | sv |
| 88-062 | trichlorophenol(2,4,6-) ($C_6H_3Cl_3O$) | r4 | A8 | HAP | B3; B6; I5 | sv |
| 25735-299 | trichloropropane, N.O.S. | | A8 | | | |
| 96-184 | trichloropropane(1,2,3-) | r4 | A8 | | | v |
| 121-448 | triethylamine | | | HAP | | |
| 126-681 | triethylphosphorothioate(o,o,o-) | | A8 | | | |
| 1582-098 | trifluralin | | | HAP | | |
| 540-841 | trimethylpentane(2,2,4-) | r5 | | HAP | | |
| 99-354 | trinitrobenzene(1,3,5-) ($C_6H_3N_3O_6$) | r5 | A8 | | | |
| 52-244 | tris(1-aziridinyl)phosphine sulfide | | A8 | | | |
| 126-727 | tris(2,3-dibromopropyl) phosphate | | A8 | | | sv |
| 72-571 | trypan blue | | A8 | | | |

| CAS No. | Chemical compounds | Risk PICs | RCRA | CAAA | Measured PICs | (A) |
|---|---|---|---|---|---|---|
| 66-751 | uracil mustard ($C_8H_{11}Cl_2N_3O_2$) | | A8 | | | |
| 1314-621 | vanadium pentoxide ($V_2O_5$) | | A8 | | | |
| 108-054 | vinyl acetate | r4 | | HAP | | |
| 593-602 | vinyl bromide | | | HAP | | |
| 75-014 | vinyl chloride ($C_2H_3Cl$) | r4 | A8 | HAP | B5; B6 | v |
| 75-354 | vinylidene chloride | r4 | | HAP | | |
| 81-812 | warfarin ($C_{19}H_{16}O_4$) | | A8 | | | |
| 81-812 | warfarin salts, when present at concentrations greater than 0.3% | | A8 | | | |
| 81-812 | warfarin salts, when present at concentrations less than 0.3% | | A8 | | | |
| 1330-207 | xylenes (isomers and mixture) | | | HAP | | |
| 108-383 | xylenes(m-) | r4 | | HAP | | |
| 95-476 | xylenes(o-) | r4 | | HAP | | |
| 106-423 | xylenes(p-) | r4 | | HAP | | |
| 557-211 | zinc cyanide ($Zn(CN)_2$) | | A8 | | | |
| 1314-847 | zinc phosphide ($Zn_3P_2$), when present at concentrations of 10% or less | | A8 | | | |
| 1314-847 | zinc phosphide ($Zn_3P_2$), when present at concentrations greater than 10%. | | | | | |
| Overall totals: | 588 compounds | 160-r4 | 414 | 190 | 53 PICs found exiting from 310 combustors | 34-v |
| | | 59-r5 | | | | 45-sv |

*A.1. Legend*

- A8: Appendix VIII to 40CFR Part 261.
- CAS: Chemical Abstract Service.
- HAP: Hazardous Air Pollutant.
- N.O.S.: Not Otherwise Specified.
- Column "Risk PICs": "r4" are compounds that the EPA/RCRA permit writers should consider requiring waste incineration facilities to sample and analyze for, to support the conduct of exposure/risk assessments [19].

- Column "Risk PICs": "r5" are additional compounds that the EPA/RCRA permit writers may also want to require the waste incineration facilities to sample and analyze for, to support the conduct of exposure risk assessments [19].
- Column "RCRA": Hazardous Constituents listed in 40CFR261 Appendix VIII under the 1976 Resource Conservation and Recovery Act.
- Column "CAAA": Hazardous Air Pollutants (HAP) listed in Title III of the 1990 Clean Air Act Amendments.
- Column "Measured PICs": PIC compounds emitted from the various combustors shown in Table 2.
- Column "(A)": "v" and "sv" mean volatile and semivolatile compounds, respectively. Information is from 40CFR268 Appendix III, 1993 and Ref. [16].

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