Lead scavengers & other carcinogens in gasoline, New Zealand 1965-1975

Questions posed and answers collated by Elizabeth O'Brien, Lead Scientist, The LEAD Group Inc, Australia

Q: What are lead scavengers and why are they used?

A: The ATSDR Agency for Toxic Substances and Disease Registry (ATSDR), US Department of Health and Human Services, May 2006, *Lead Scavengers Compendium: Overview of Properties, Occurrence, and Remedial Technologies,* https://www.epa.gov/sites/production/files/2015-03/documents/compendium-0506.pdf states:

> **EXECUTIVE SUMMARY**
> **Introduction**
> Ethylene dibromide (EDB) and ethylene dichloride (EDC; also known as 1,2-dichloroethane or 1,2-DCA) are synthetic organic chemicals used in leaded gasoline as "lead scavengers" to prevent the buildup of lead deposits that foul internal combustion engines. Even though leaded gasoline for on-road automobiles has not been used for more than a decade, leaded gasoline containing lead scavengers is still used as aviation gasoline (Avgas) and in some off-road applications such as automobile racing fuel.

Q: When were lead scavengers first added to leaded fuel additives?

A: ATSDR (May 2006) states:

> **Historical Uses of Lead Scavengers**
> The use of EDB as a lead scavenger began in 1925. Beginning in the 1940s, EDB was partially replaced with EDC as a cost saving measure.

Q: at what point in the manufacturing process of the lead additive for fuel are lead scavengers added?

A: The Toxnet - Hazardous Substances Data Bank (HSDB), Toxicology Data Network, US National Library of Medicine, US National Institutes of Health entry (reviewed May 8, 2008) on *TETRAETHYL LEAD - CASRN: 78-00-2* states:

> **General Manufacturing Information:**
> Immediately following the production stage, the manufacturer is responsible for blending the lead alkyl with ethylene dichloride or dibromide to create the full gasoline additive package ...[European Chemicals Bureau; IUCLID Dataset, Tetraethyllead (CAS # 78-00-2) p.4 (2000 CD-ROM edition). Available from, as of January 30, 2008: http://esis.jrc.ec.europa.eu/]

Formulations/Preparations:

Composition: Tetraethyl lead (TEL) /as additive to gasoline/: 61.49 wt %; Ethylene dibromide: 17.86% by wt; Ethylene dichloride: 18.81% by wt; Dye, stabilizer, kerosene, and inerts: 1.84% by wt. [Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996, p. 1690] **PEER REVIEWED** ...

A typical motor mix for automotive gasolines consists of about 62% tetraethyl lead (TEL), 18% ethylene dibromide, 18% ethylene dichloride, and 2% of other ingredients, such as dye, petroleum solvent, and stability improver. For overall best performance of aviation piston engines, the scavenger consists entirely of ethylene dibromide, and a typical aviation mix includes about 61-62% TEL, 35-36% ethylene dibromide, and 3% of dye, solvent, inhibitor, etc. [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984., p. 11(80) 665] **PEER REVIEWED**

...some tetraethyl lead (TEL) is mixed directly with lead scavengers (usually ethylene dichloride & ethylene dibromide) to make one type of additive containing about 65% TEL. Another type of additive is made by mixing TEL with tetramethyl lead to produce physical mixtures containing 10-75% tetramethyl lead (TML). [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V2 P151 (1973)] **PEER REVIEWED**

Impurities:
Tetraethyl lead used as an anti-knock compound in gasoline ... contains ethylene dibromide, ethylene dichloride, dye, stabilizer, kerosene, and inerts as impurities. [Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996., p. 1690] **PEER REVIEWED**

Q: were lead scavengers incorporated into the fuel lead additives made by Associated Octel and imported into New Zealand?

A: Nick Wilson and John Horrocks (January 2008) in *Lessons from the removal of lead from gasoline for controlling other environmental pollutants: A case study from New Zealand*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2263033/ wrote (referring to the period 1994-1995):

Lead in petrol 'small factor'

Northland's Medical Officer of Health, Dr J. S. McKenzie-Pollock, believes the issue of lead content in petrol has been blown out of proportion.

Responding to a recent statement by the Friends of the Earth condemning Government moves to reduce lead levels, Dr McKenzie-Pollock said today that lead in petrol was only a small percentage of the lead in the environment.

"I would put the emission from cars as maybe about 10 per cent of the lead problem," he said.

Other sources such as some pottery glazes — "a lot of the Friends of the Earth people are potters" — old paint on old houses and solder were more of a problem, he said.

FOE's national organiser, Mr Roger Wilson, described the proposal to reduce lead levels in petrol to 0.45 grams a litre as "totally unsatisfactory."

Expansion plans for the Marsden Pt oil refinery failed to recognise the dangers of adding lead to petrol, he said last week.

"All that would happen is that small lead particles would be released from exhausts, and these are the particles that are most easily absorbed by breathing," he said.

He said the current level in the United Kingdom was also 0.45 grams per litre. This was worrying enough in that country for a group of parents to be suing the oil companies in a current court case claiming damage to their children.

The health risks from lead were now well known, Mr Wilson said. But, he claimed, leaded petrol contained the further danger of the additive ethylene dibromide.

This was shown in a study by the United States National Cancer Institute, reported last year, to cause stomach cancers in rats and mice, he said.

"Concentrations of this compound have been found in the air near petrol stations and along well-travelled highways."

Not surprisingly, the industry ignored the existing source of likely carcinogens in leaded gasoline (according to the knowledge at this time). These were the "scavengers" ethylene dibromide and ethylene dichloride [61,62], added to leaded gasoline in order to help prevent a build-up of lead deposits in the cylinders.

At left, 19790507 Advocate newspaper article Lead in petrol small factor - mentions the lead scavenger ethylene dibromide as being carcinogenic in animal studies.

Q: Are lead scavengers considered to be carcinogenic?

A: ATSDR (May 2006) states:

Toxicology of Lead Scavengers
...EPA has determined that both EDB and EDC are probable human carcinogens. The U.S. Department of Health and Human Services has determined that both EDB and EDC may reasonably be expected to cause cancer.

5.3.2.3 Carcinogenicity

EDB:... Carcinogenic effects were observed in workers who were occupationally exposed to EDB, primarily via the respiratory route (Ref. 5-1). EPA has designated EDB as a probable1 human carcinogen (Ref. 5-20), and the U.S. Department of Health and Human Services (DHHS) has determined that EDB may be reasonably anticipated to be a carcinogen (Ref. 5-4).

EDC: Several agencies have determined that EDC has carcinogenic potential; DHHS has determined that EDC may reasonably be expected to cause cancer; EPA has determined that EDC is a probable human carcinogen while the International Agency for Research on Cancer (IARC2) considers EDC to be a possible3 human carcinogen (Ref. 5-5). In animal studies, increases in the occurrence of cancers of the stomach, mammary gland, liver, lung, and endometrium have been observed (Ref. 5-5)...

The ATSDR (May 2006) references cited above are:

5-1 Agency for Toxic Substances and Disease Registry (ATSDR). 1992. Toxicological Profile for 1,2-Dibromoethane. U.S. Department of Health and Human Services, Public Health Service.

5-4 ATSDR. 2004. ToxFAQs™: 1,2-Dibromoethane. [*Editor's note:* Previously: Website Accessed on March 26, 2004. http://www.atsdr.cdc.gov/tfacts37.html; Website Accessed on September 7, 2019. https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=131 - Page last updated: March 3, 2011: "**Affected Organ Systems:** Dermal (Skin), Hepatic (Liver), Renal (Urinary System or Kidneys), Reproductive (Producing Children) **Cancer Classification:** NTP: Reasonably anticipated to be a human carcinogen. EPA: Llikely to be carcinogenic to humans based on strong evidence of carcinogenicity in animals and inconclusive evidence of carcinogenicity in an exposed human population. IARC: Probably carcinogenic to humans"]

5-5 ATSDR. 2004. ToxFAQs™: 1,2-Dichloroethane. [*Editor's note:* Previously: Website Accessed on August 17, 2004. http://www.atsdr.cdc.gov/tfacts38.html; Website Accessed on September 7, 2019. https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=110 - Page last updated: March 3, 2011: "**Affected Organ Systems:** Hepatic (Liver), Renal (Urinary System or Kidneys) **Cancer Classification:** EPA: Probable human carcinogen. IARC: Possibly carcinogenic to humans. NTP: Reasonably anticipated to be a human carcinogen"]

5-20 EPA. 2004. Toxicological Review of 1,2-Dibromoethane: In Support of Summary Information on the Integrated Risk Information System (IRIS). EPA 635/R-04/067.

A: the National Toxicology Program (NTP) (1978) *Bioassay of 1,2-dibromoethane for possible carcinogenicity*, in Natl Cancer Inst Carcinog Tech Rep Ser. from https://www.ncbi.nlm.nih.gov/pubmed/12830212 states:

> A bioassay for possible carcinogenicity of technical-grade 1,2-dibromoethane was conducted using… rats and… mice… There was a positive association between increased dosage and accelerated mortality in rats and mice of both sexes…. All male mice and high dose female mice died or were sacrificed by week 78, while the low dose mice were observed for an additional 37 weeks after a 53-week period of chemical administration. In rats squamous-cell carcinomas of the forestomach were observed in 45/50, 33/50, 40/50 and 29/50 of the low dose males, high dose males, low dose females and high dose females, respectively, while none were observed in controls…. . Each of these incidences was statistically significant. These lesions were seen as early as week 12 in rats and week 24 in mice; they invaded locally and eventually metastasized. Increased incidences of hepatocellular carcinomas were observed in dosed rats, but the incidence of this neoplasm was significant only in females. Increased incidences of hemangiosarcomas were observed in each dosed rat group, but was statistically significant only in males, where they appeared as early as week 26. Early development of squamous-cell carcinomas which invaded and metastasized was also observed among mice. Squamous-cell carcinomas were found in 45/50, 29/49, 46/49 and 28/50 of the low dose males, high dose males, low dose females, and high dose females, respectively, but none were found in controls. Each of these incidences was statistically significant.

A: In L S Gold, G M Backman, N K Hooper, and R Peto, *Ranking the potential carcinogenic hazards to workers from exposures to chemicals that are tumorigenic in rodents,* Environ Health Perspect. 1987 Dec, two lead scavengers (out of 41 chemicals which cause tumours in rats) were ranked first (ethylene dibromide) and second (ethylene dichloride) for potential carcinogenic hazards to workers

(https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1474483/?page=1), and the discussion (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1474483/?page=8) points out that we have little knowledge of the **potential interactions of individual agents in chemical mixtures** [like the lead additive for fuel which contains both lead scavengers and tetra-alkyl lead, or like leaded petrol, which contains the lead additive mixture plus benzene, ranked 10th of the 41 chemicals] and with other carcinogenic exposures such as smoking:

> For 41 chemicals there exist both reasonable data on carcinogenic potency in experimental animals and also a defined Permissible Exposure Level (PEL), which is the upper limit of legally permissible chronic occupational exposure for U.S. workers. These 41 agents are ranked by an index that compares the permitted chronic human exposure to the chronic dose rate that induces tumors in 50% of laboratory animals. This index, the Permitted Exposure/Rodent Potency index, or PERP, does not estimate absolute risks directly, but rather suggests the relative hazards that such substances may pose… Ranked by PERP, these chemicals are: ethylene dibromide, ethylene dichloride, 1,3-butadiene, tetrachloroethylene, propylene oxide, chloroform, formaldehyde, methylene chloride, dioxane, and benzene.

Q: do lead scavengers have other health impacts in humans?

A: ATSDR (May 2006) states:

> **Toxicology of Lead Scavengers**
> …EDC [affects] the human central nervous system, lungs, and liver as well as… the cancer risk …EDB [affects] the human stomach, adrenal glands, reproductive system, respiratory system, nervous system, liver, heart, and kidneys as well as… the cancer risk…
>
> ***5.3.2.4 Reproductive and Developmental Effects***
> ***EDB:*** There is inconclusive but suggestive evidence that EDB may cause abnormal sperm and decreased male fertility (Ref. 5-1). A study of agricultural workers exposed to EDB used as a fumigant revealed statistically significant decreases in sperm counts and in the percentages of viable and motile sperm as well as significant increases in sperm with morphological abnormalities (Ref. 5-1). Another study concluded that human exposure to EDB concentrations between 0.5 and 5.0 ppm was associated with lower sperm counts (Ref. 5-8)…
>
> ***5.3.2.5 Mutagenic Effects***
> ***EDB:*** EDB is a potent mutagen and can cause genetic damage, including point mutations, chromosomal aberration, and primary DNA damage in both *in vivo* and *in vitro* systems. Chromosomal aberrations and sister chromatid exchanges were seen in cultured mammalian cells (Ref. 5-22).
>
> ***EDC:*** *In vitro* genotoxicity studies have shown that EDC can interact with human DNA and produce point mutations in human cells (Ref. 5-3).

Q: what's the best way for an employer to get away with exposing worker's to a probably or possibly carcinogenic chemical and rest easy that they won't be liable for compensation payouts?

A: expose the workers to a mixture of probably or possibly carcinogenic chemicals, such as the mixture that is leaded petrol. And ensure that no industrial process only exposes a worker to a single toxic chemical. That way, the worker can never prove that their cancers or other health impacts were caused by any one carcinogen or hazardous substance, and the IARC can write things like the following in their monographs.

Reference: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, 1989, VOLUME 45 Occupational Exposures in Petroleum Refining; Crude Oil and Major Petroleum Fuels: Gasoline http://publications.iarc.fr/63 states:

Table 1. Composition by hydrocarbon type of typical automotive gasolines[a]

Composition	Range
Alkanes	4–8 wt %
Alkenes	2–5 wt %
Isoalkanes	25–40 wt %
Cycloalkanes	3–7 wt %
Cycloalkenes	1–4 wt %
Total aromatics	20–50 wt %
Benzene	0.5–2.5 wt %
Paraffins (naphthenes)	30–90 vol. %
Olefins	0–30 vol. %
Aromatics	10–50 vol. %

[a]Adapted from CONCAWE (1985, 1987)

4.5 Evaluation
...Benzene is carcinogenic to humans (Group 1)
...
Overall evaluation
Gasoline is possibly carcinogenic to humans (Group 2B).

Reference: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 120: Benzene (2018), http://publications.iarc.fr/576 states:

BENZENE
6.1 Cancer in humans
There is *sufficient evidence* in humans for the carcinogenicity of benzene. Benzene causes acute myeloid leukaemia in adults.

Positive associations have been observed for non-Hodgkin lymphoma, chronic lymphoid leukaemia, multiple myeloma, chronic myeloid leukaemia, acute myeloid leukaemia in children, and cancer of the lung.

5.2.6 Other cancers [other than lung cancer]
Occupational cohort studies also reported data for several other cancer types and tumour sites, including cancer of the: nasal cavity, pharynx, larynx, and related sites; oesophagus; stomach; colon, rectum, and anus; pancreas; kidney; liver and biliary tract; prostate; bladder, brain, and central nervous system; and skin.

6.3 Overall evaluation
Benzene is *carcinogenic to humans (Group 1)*.

Ref: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, 1999, VOLUME 71, Re-evaluation of Some Organic Chemicals, Hydrazine and Hydrogen Peroxide, https://publications.iarc.fr/89 states:

1,2-DICHLOROETHANE
…
4. Other Data Relevant to an Evaluation of Carcinogenicity and its Mechanisms
…
4.3 Reproductive and developmental effects
4.3.1 *Humans*
No data were available to the Working Group.
…
4.4 Genetic and related effects
4.4.1 *Humans*
No data were available to the Working Group.
…
5.2 Human carcinogenicity data…All the cohort studies included workers with potential exposure to multiple agents and were not able to examine the excess risk associated with 1,2-dichloroethane."

ETHYLENE DIBROMIDE (1,2-DIBROMOETHANE)
…
4. Other Data Relevant to an Evaluation of Carcinogenicity and its Mechanisms
…
5.2 Human carcinogenicity data
Three cohort studies have included workers exposed to ethylene dibromide, but because of their low statistical power and/or lack of information about individual exposures, little can be concluded about the carcinogenicity of this compound in humans.
…

5.5 Evaluation

There is *inadequate evidence* in humans for the carcinogenicity of ethylene dibromide.

There is *sufficient evidence* in experimental animals for the carcinogenicity of ethylene dibromide.

Overall evaluation

Ethylene dibromide is *probably carcinogenic to humans (Group 2A).*

In making the overall evaluation, the Working Group took into consideration that ethylene dibromide is genotoxic in a broad range of in-vitro and in-vivo assays and binds covalently with DNA *in vivo*.

Q: If you are a manufacturer of mixtures of hazardous chemicals (like the lead additive with its lead scavengers, that is mixed with petrol to make leaded petrol), what's the best way to control information about workers' exposures?

A: be the only source of the information. For example, Associated Octel (now called Innospec, previously called Associated Ethyl Company Limited of London), manufacturer of the lead additive for petrol, wrote in 1994, in **Letter and Briefing from Associated Octel to Consumer's Health Forum of Australia,** March 24, 1995, titled "GASOLINE COMPOSITION: NO SUCH THING AS A "GREEN" FUEL" by Dr David Gidlow, Company Medical Officer, Associated Octel:

> Associated Octel - one of the world's leading fuel technology companies - has been at the forefront in pressing for a re-evaluation of fuel composition and its risk to health. Indeed, the company's Worldwide Gasoline Survey is the only source of authoritative information on motor fuel composition available in the world.

Q: How can a lead scavenger manufacturer best increase the volume of sales?

A: by buying a tetra-ethyl lead manufacturer. According to Jamie Lincoln Kitman in "The Secret History of Lead", March 20, 2000, https://www.thenation.com/article/secret-history-lead/ - in The Nation:

> In 1989 Octel was sold to Great Lakes Chemical of West Lafayette, Indiana, makers of bromine and brominated chemicals, including EDB, the chemical scavengers used in ethyl gasoline to clear lead deposits from engines. In 1997 Great Lakes Chemicals spun off Octel into a separate company, which in 1998 was sold for $430 million to a highly leveraged management team led by Octel's managing director (now CEO), Dennis Kerrison.

Q: How much tetra-alkyl lead (total of tetra-ethyl lead and tetra-methyl lead) and lead scavengers are we talking about in New Zealand?

A: again, Jamie Lincoln Kitman (2000) states:

> Off the record, company officials admit they could be selling [tetra-alkyl] lead in 2020 and beyond. Until then, Octel, "through the specialist facilities of Octel Environmental, provides a range of decontamination, destruction, removal and

recycling services to refineries throughout the world to help to reduce the environmental impact of toxic lead residues." Under its Product Stewardship Programme--"a public service," Octel calls it--fifty tons of lead alkyl sludge were removed from New Zealand refineries as part of a cleanup beginning in 1996. Octel had supplied the refineries with 4,000 tons of TEL annually for years.

Q: when Brian Arndt was working during refinery shutdowns (turnarounds), what hazardous chemicals (including carcinogens) was he likely exposed to?

A: Appendix 5: Examples of Hazardous Agents...from *Management of Occupational Health Risks during Refinery Turnarounds*, by M. Molyneux, D. Bonte, P. De Wilde, J. Ilinyi, T. Kaitale, A. Tiltnes, B. Simpson, J. Urbanus (Technical Co-ordinator), CONCAWE (established 1963), Brussels 2000, https://www.concawe.eu/wp-content/uploads/2017/01/2002-00233-01-e.pdf - lists the following hazardous agents which require management during refinery shut-downs:

CRUDE OIL
· Hydrogen sulphide
· Sulphur dioxide
PETROLEUM GASES
· Propane
· 1.3-Butadiene
NAPHTHA / GASOLINE / CONDENSATE
· Hydrocarbons C4-C11
· Benzene
· n-Hexane
KEROSENE / MID DISTILLATES
· Hydrocarbons C9-C25
· Gasoils (cracked and unspecified)
HEAVY BOTTOMS
· Heavy fuel
· Bitumen
· PAH / Coke
LUBRICANTS
· Unrefined oils
· Unrefined greases
EXTRACTION SOLVENTS
· Furfural
· Toluene
· Ketones, e.g. MEK
· Chlorinated solvents
· Phenol
SULPHUR
ADDITIVES
PROCESS
· Amines / Ammonia
· Phosphates / H_2PO_5
· Caustic / KOH
· Chlorides / HCl
· Sulphuric acid
BOILER WATER
· Hydrazine

FUEL
· Oxygenates
· TEL / TML
· Octylnitrate
· Mercaptans
SURFACE STRIPPING / COATING
ABRASIVE BLASTING
· Dust
· Lead
HYDROBLASTING
· Polluted water / aerosol
APPLICATION OF PROTECTIVE COATINGS
· Two part (reactive) coating
· Solvent based coating
CHEMICAL CLEANING
· Corrosives
· Solvents
WELDING & CUTTING
FUMES
· Lead
· Metal oxides (Galvanized steel)
· Stainless steel (Ni, Cu)
· Carbon steel
· Surface coatings
GASES
· Ozone
· NOx
· Carbon monoxide
INSULATION REMOVAL / INSTALLATION
MMMF
· Glasswool
REFRACTORY CERAMIC FIBRES
ASBESTOS
POLYURETHANE
· Isocyanates
CATALYST REMOVAL / LOADING / REGENERATION

ACTIVATED ALUMINA
HEAVY METALS
· Molybdenum
· Cobalt
· Platinum
· Vanadium
· Antimony
· Nickel
ORGANIC SULPHIDES
· Dimethyl disulphide
· Dimethyl sulphide

CHLORINE
CHLORINATED HYDROCARBONS
· Perchloroethylene
HYDROGEN FLUORIDE
SULPHURIC ACID
UTILITIES
NITROGEN
HEAT TRANSFER OILS
HYDRAZINE
POLYAMINES Eye
PCBs

Q: which other carcinogens and mutagens does Shell list as chemical hazards for refinery workers?

A: *Table 7a (i) Refinery: Chemical Agent Inventory: Examples of chemical agents and the principal areas in which they may occur*, from "Shell Occupational Health Hazard Inventory", web-published by Petroleum Development Oman on 6th May 2012, available as link at: https://www.pdo.co.om/hseforcontractors/Health/Documents/Forms/AllItems.aspx?Paged=TRUE&p_SortBehavior=0&p_FileLeafRef=PDO%20HEALTH%20HAZARD%20REGISTER%2012201 6%2exlsx&p_ID=370&RootFolder=%2fhseforcontractors%2fHealth%2fDocuments%2fHRAs&Page eFirstRow=31&&View={CA6B6393-9515-41E4-8223-61BADE2DAB33} includes among refinery carcinogens and mutagens:

> Products: Gasolines (contain benzene); Streams containing PCAHs (Polycyclic Aromatic Hydrocarbons) - Gas oils, Heavy fuel oils, Cycle oils, Crude oil; 1-3 Butadiene (may contaminate LPG streams)
>
> Internal streams: Low boiling naphthas (benzene); Streams containing PCAHs including Base oils, Gasoil, Heavy fuel oil, Long/short residues, Waxy distillate
>
> Raw materials: Crude oil (PCAHs and benzene); Low boiling naphthas (Benzene); Benzene heart cut; Long residues (PCAHs); Waxy distillate (PCAHs); Furfural extract (concentrated PCAHs); Gas oils (PCAHs); Light cycle oils (PCAHs)
>
> Auxilliary chemicals: Hydrazine salts; crystalline silica (calcined diatomaceious earths, filter aids); Fuel oils (PCAHs furnace heating)
>
> By-product/Wastes: Furfural extract (concentrated PCAHs); Slops containing PCAHs; Coke (PCAHs); Sludges from black oil tank bottoms (PCAHs); Furnace residues (nickel compounds); Some used transformer oils (PCBs)
>
> Maintenance, construction and cleaning: Asbestos (gaskets, insulation, partitions); Some man-made vitreous fibres (furnace linings, insulation); Chromates (some paints); Chromium (VI) stainless steel welding fume (e.g. furnace tubes); Nickel in anti-seize compounds; Used engine oil (PCAHs).
