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Benzene SOP factors

The RMA reviewed all the SOPs that had benzene exposure factors and issued amendments that took effect on 4 April 2016 (Instruments 31 to 40 of 2016). Since that time there have been further changes to some SOPs with benzene factors. The information in this bulletin is provided to assist delegates in applying benzene factors in SOPs.

SOPs with benzene factors

The following SOPs contain factors for 'being exposed to benzene'.

- Acute lymphoblastic leukaemia/lymphoblastic lymphoma*
- Acute myeloid leukaemia
- Aplastic anaemia
- Chronic lymphocytic leukaemia/small lymphocytic lymphoma*
- Myelodysplastic syndrome
- Myeloma*
- Non-Hodgkin lymphoma*
- Pure red cell aplasia

* Benzene factor in RH SOP only

The SOP factors and associated definitions specify that exposure may occur via:

- skin contact with liquids containing > 1% benzene; or
- ingestion of liquids containing > 1% benzene; or
- inhalation of benzene vapour:

(i) at an ambient 8-hour time-weighted average benzene concentration exceeding five parts per million (ppm); or
(ii) to a cumulative total exposure, expressed in "ppm-years".

The factors specify exposure for either 1,250 or 2,500 cumulative hours, except for:

- aplastic anaemia and pure red cell aplasia which require exposure on 30 (RH) or 45 (BOP) days; and
- the cumulative total exposure factor, which requires either 5 or 10 ppm-years.

Aplastic anaemia and pure red cell aplasia are the only non-neoplasms with a benzene factor. These conditions are associated with shorter term but generally more intense benzene exposure. The aplastic anaemia SOPs were updated in 2020 and new SOPs for red cell aplasia were created at that time. Previously the aplastic anaemia SOP specified exposure to liquids that contained > 5% benzene, but that requirement was reduced to > 1% in 2020.

Benzene exposure – general

Benzene occurs naturally in fossil fuels. It is also produced by the combustion of organic matter such as wood, coal and petroleum products.

All people have low level benzene exposure from the environment. The major source is emissions/exhaust from petrol engine vehicles. Cigarette smoke is a source of exposure, particularly for active smokers. Some furnishings, solvents and adhesives also contain benzene and can contribute to benzene exposure when used indoors. Trace amounts are found in food and drinking water. Benzene breaks down in the environment and doesn't accumulate.

Benzene has been used as a component of inks in the printing industry, as a solvent for organic materials, as a starting material and intermediate in the chemical and drug industries (e.g. to manufacture rubbers, lubricants, dyes, detergents, pesticides), and as an additive to petrol. The primary use of benzene today is in the manufacture of organic chemicals.

Occupational exposure to benzene occurs via inhalation or dermal absorption of solvents in the rubber, paint (including paint applications) and plastics manufacturing industries and in steel production. It is used as a solvent and reagent in laboratories. Exposure also occurs during crude-oil refining and chemical manufacturing. Workers involved in the transport and handling of crude oil and petrol, as well as street workers, taxi drivers and others employed at workplaces with exposure to exhaust gases from motor vehicles also experience exposure to benzene. Fire-fighters may also be exposed from the burning of organic matter and synthetic polymers like polyvinyl chloride and urethane foam.

Occupational and environmental exposures to benzene have fallen very substantially over time (since the middle of the last century), as health risks have become apparent, regulations tightened and benzene use in products lowered or eliminated.

Exposure in the environment is measured in parts per billion (ppb) of benzene vapour in air. 1000 ppb = 1 ppm. Daily mean exposure in Australian cities has been estimated at around 1 to 5 ppb (0.001 to 0.005

ppm). Higher exposure levels occur in e.g. areas with high traffic volumes, in service stations and in some industrial areas. In smokers mean exposure is around 15 ppb.

Occupational exposure levels

The current workplace exposure limit for benzene (vapour) in Australia is 1 ppm of air averaged over an 8-hour period.[1] This was lowered from 5 ppm in approximately 2003.

Estimated long-term exposure levels: [2,3]

- Chemical industry and laboratory workers — < 0.5 ppm
- Petroleum industry – oil and gas production — < 0.1 ppm
- Petroleum industry – refining, distribution and marketing — < 0.7 ppm
- Steel and associated industries — < 0.7 ppm
- Vehicle mechanics — < 0.2 ppm
- Workers in roadside or in-vehicle environments — < 0.05 ppm
- US Air Force fuel maintenance workers — < 0.1 ppm
- US Air Force fuel handling and distribution workers — < 0.002 ppm

A source for comparable long-term levels in fire-fighters has not been identified, but mean short term benzene exposure in one study of civilian firefighters was < 0.4 ppm. [3]

Benzene concentrations in fuels

Petrol

- Current unleaded petrol contains approximately 0.6% benzene by volume. The Australian maximum has been 1% since 2006.
- In 1998 the average was 2.6% in unleaded petrol and 3.3% in premium unleaded petrol.
- Leaded petrol was phased out from 1986. Leaded petrol typically contained around 2.5% benzene.

Diesel

Typically contains 0.003 to 0.1% benzene.

Military aviation fuels

<u>Jet fuels /AVTUR</u>

JP 8: a.k.a. NATO code F-34, is the military equivalent of the Jet A-1 fuel used by commercial airlines. It is the standard fuel used in military jet aircraft since around 1990. It is kerosene based. It is also widely used in military settings as a substitute for diesel. In contains typically less than 0.02% benzene. In one US study the mean concentration of benzene in JP 8 was 0.0051%.[4]

JP 4: a.k.a. NATO code F-40, was a commonly used fuel prior to the introduction of JP 8. It was a kerosene gasoline mix and contained normally < 0.5% benzene.[5]

<u>AVGAS</u>:

AVGAS is aviation gasoline, used by piston engine aircraft. Currently available AVGAS (100, or 100LL) contains < 0.1% benzene. Historically, AVGAS made in Australia (since 1955) has contained 0 to 3% benzene, varying with refinery. Freezing point requirements set a limit on the maximum benzene content. [6] AVGAS imported into Australia prior to 1955 is estimated to have contained 0 to 5% benzene by volume.

Liquids containing benzene > 1% by volume

Liquids that contained benzene > 1% by volume include:*

- Leaded and unleaded petrol in Australia prior to 2006
- AVGAS used in WW1 and WW2
- Some AVGAS refined in Australia from 1955.
- Some paint strippers, rubber cements, spot removers and other commercial hydrocarbon-containing products used up to approximately the 1980s.
- Engine cleaning fluid containing benzol. This was known to have been used in RAAF workshops in Australia in WW2.[7] Whether the army used this product is currently unknown. It was not used on RAN ships.

* These are known examples, not a complete list.

Liquids/products containing < 1% benzene by volume

Liquids that contain benzene < 1% by volume include:[#]

- present day aviation fuel
- diesel oil
- fuel and heating oils
- kerosene
- liquified petroleum gas (LPG)
- lubricants and grease
- fuels, solvents and other products used in RAN engine rooms – the volatility and combustibility of benzene-containing products precluded their use in this environment.
- Paint thinners and paint remover used by the RAAF in WW2 (benzene-containing products were not used, by RAAF regulation).[7]

[#] These are known examples of hydrocarbons low in benzene, not a complete list.

Current/recent military benzene exposure levels

Current or recent military service is generally not associated with exposure to potentially harmful levels of benzene. Of particular note – currently used military fuels have low levels of benzene (much lower than petrol) and are generally not a significant source of exposure. There may be specific occupational categories that are or were associated with increased exposure. The circumstances in each individual case will need to be carefully considered.

Measured benzene vapour in air levels for specific military settings are highly unlikely to be available.

As a generalisation, the further back in time service occurred the greater the potential for significant benzene exposure.

Applying the SOP factors

Specific detailed information about a person's benzene exposure will typically not be available and so applying the SOP factors is unlikely to be straightforward. The factors and associated definitions provide for exposure via three pathways: skin contact; ingestion; and inhalation.

Skin contact with products containing > 1% benzene could have occurred in a variety of situations, such as washing hands in petrol (pre-2006) and manually using liquid products containing > 1% benzene in occupational settings without adequate skin protection. Such products were much more likely to have been used in the middle part of last century than in the last several decades. Prolonged skin contact is the pathway that (in general) provides the best prospects of meeting the SOP requirements.

Ingestion: Food and beverages may contain trace amounts of benzene (much, much lower than 1% by volume). Ingestion of any liquid containing 1% benzene would be unintentional or perhaps a deliberate act of harm. Ingestion of liquids containing > 1% benzene for 1,250 or 2,500 hours is highly implausible.

Inhalation of benzene vapour at an 8-hour time-weighted average (TWA) benzene concentration exceeding five ppm is and was highly unlikely outside of some specific industrial settings or in particular circumstances in poorly-ventilated, enclosed spaces. A study by Glass et al on historic benzene exposure in Australia[6] reported maximum exposure for a wide range of occupational activities that were all < 5 ppm (table 4, p. 313). Cumulative exposures of 5 or 10 ppm-years, via exposure to levels of benzene below 5 ppm were reported in the Glass et al study, but required long-term exposure. On that basis the SOP factor covering intense inhalational exposure (at an 8 hour TWA of > 5 ppm) is unlikely to be met, but the levels in the other inhalation factor, for cumulative exposure (in ppm-years) regardless of intensity might be achievable.

Calculations of exposure specified in SOP factors

8-hour time-weighted average

This is a calculation of the average amount of exposure to a chemical vapour using the baseline of an 8 hour workday. A time-weighted average (TWA) exposure is expressed in units of parts per million (ppm).

An 8-hour TWA is calculated by multiplying the level of exposure on a given exposure day (in ppm) by the duration of exposure (in hours) on that day and then dividing by 8 (hours). In the case where the level of exposure varies during a day, then:

- (i) a calculation is made for each period of exposure;
- (ii) all exposure periods for a given day are summated; and
- (iii) the total is divided by 8.

For example, exposure to 10 ppm for 4 hours gives an 8 hour TWA of 5 ppm, and exposure to 10 ppm for 2 hours and then 4 ppm for 6 hours on the same day gives an 8 hour TWA of 5.5 ppm.

The SOP factor then requires 1250 or 2500 cumulative hours of such exposure. So, hours of exposure on days when the 8 hr TWA exceeds 5 ppm can be counted toward the cumulative total.

ppm-year

One ppm-year is exposure to an average concentration of 1 ppm for 8 hours a day for 250 days a year, or the equivalent.
Some examples: 5 ppm-years equals exposure to:

- 1 ppm for 8 hours a day for 1250 (250 x 5) days, or
- 5 ppm for 4 hours per day for 500 days, or
- 10 ppm for 8 hours a day for 125 days.

As noted above, specific individual information that would allow these calculations to be made is highly unlikely to be available.

References / Further reading

1 http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/772/Workplace-exposure-standards-airborne-contaminants.pdf

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