Ozone (O₃) exposure—occupational health implications

Ganyk Jankewicz
MPL Group (SA), Thebarton, SA

Introduction
A relatively recent usage of ozone in the wine production industry (in some organisations) has been for sanitisation of wine barrels (and other vessels). The method being employed to generate the ozone has used various types of ozone generators, working on the basis of creating ozone from corona discharge and capturing the ozone in mains water for use as a disinfecting spray. This author has only been involved with the trial of one such ozone generator on one occasion, and as such, this paper does not intend to comment on the pros and cons of different ozone generators—only implications of ozone release and possible subsequent risks to employees from exposure.

Chemical/physical properties of ozone
Molecular Formula: O₃
Molecular Weight: 48
Bluish Gas
Melting Point: −193°C
Boiling Point: −119°C
Vapour Density: 1.66 (at 25°C)
Conversion factor at 25°C: 1 ppm = 1.96 mg/m³
Odour Threshold: less than 2 ppm
Powerful oxidising agent

Background Concentrations
Ozone is produced in the upper atmosphere by the action of ultraviolet radiation (from the sun) with oxygen (O₂) to form ozone (O₃), providing an absorbing layer to filter out a significant amount of harmful ultraviolet radiation.
Ozone is also produced as a photochemical oxidant from the interaction of reactive organic chemicals.
• Reactive organic compounds (ROC) + UV (ultraviolet from sunlight) + NO (primarily from exhaust emissions) → NO₂
• NO₂ + UV → NO + O·
• O· + O₂ → O₃
• NO + O₃ ↔ NO₂ + O₂

The National Health and Medical Research Council (NH & MRC) 1995 ambient air quality goals for ozone are as follows:
- a one hour average of 210 µg/m³ (equivalent to 0.1 ppm)
- a four hour average of 170 µg/m³ (equivalent to 0.08 ppm)

The NH & MRC also recommends that a public warning (alert) should be given if ozone levels are expected to rise about 500 µg/m³ (0.25 ppm)
The 1994 WHO Air Quality Guideline for ozone is an eight-hour average of 0.06 ppm

Major uses/occupational exposures
Ozone is used or produced in a number of processes in the occupational environment.
• disinfectant for air
• disinfectant for water
• produced during arc welding, photocopying, use of ionisers
• for bleaching textiles, oils and waxes

Health effects
Ozone is a powerful oxidant which, during short-term episodes of air pollution exposure, can produce the following respiratory symptoms:
• respiratory symptoms (eg. cough, wheeze)
• more rapid, shallow breathing
• decreased inspiratory capacity
• increased airway resistance
• airway hyper-responsiveness to non-immunologic stimuli (eg. breathing cold air)

The effect for most people at concentrations of 0.08–0.12 ppm is believed to be only slight, although susceptible individuals (eg. asthmatics) may have significant reactions.
Evidence from a range of studies indicates a reduction in lung function from exposure to sufficient ozone. From animal studies, the primary site of acute injury is the lung, with pulmonary congestion, oedema and haemorrhage at high acute exposures.
Other significant acute effects from excessive exposure to ozone include dryness of the throat, irritation of the mucous membranes of the eyes and nose, and headaches.
Epidemiological studies looking at exposed populations suffer shortcomings of either lack of quantification of airborne levels of ozone, or the inability to control for parallel exposure to the potential numerous other airborne agents.
However, the US EPA commented on one of the more informative studies that, ‘It fairly can be concluded that if there is an effect of exposure to ozone on the occurrence of the COPD/AOD (Airway Obstructive Disease) symptom/disease complex as defined in these studies, such an effect is occurring at exposure levels at or below 0.12 ppm’.
Although chronic ozone exposure (in excess of 1 ppm) has been reported to result in bronchiolitis and bronchitis in animals, no indication of an excess cancer risk was found.
On the basis of a range of information of health effects from exposure to ozone, including US EPA data; a range of Threshold Limited Values (TLVs) was recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), that incorporates the effects of ozone concentration, workload and cumulative exposure duration.

It is of interest to note that these are probably the first TLVs to incorporate workload. It is also interesting to note that these occupational exposure standards are in the same range as those set by environmental authorities, which must cater for the general population including children.

Traditionally, occupational exposure standards have been divided by factors of 100 or 30 for setting environmental inhalational standards for chemical substances/pollutants.

### Monitoring of Ozone

For direct-reading instruments measuring ozone, two methods are used, ultraviolet absorption spectrometry and chemiluminescence.

Australian Standards AS3580.6.1 ‘Determination of Ozone—Direct-reading instrument method’ outlines the minimum specifications and tolerance to interference from other gases to provide a minimum detection limit of 0.01 ppm.

The direct reading meters have generally been designed for environmental measurements rather than for occupational exposure. While there are a couple of smaller hand-held meters that purport to read ozone, the author advises caution either in their use, or taking for granted the reading obtained. The major problems with such meters are:

- interferences with other gases (which may cause considerable reliability problems when reading down towards 0.05 ppm)
- their calibration.

It is suggested that information regarding these issues be sought from the manufacturer/supplier of the meter prior to use or purchase.

Another technique for monitoring ozone in air is by the use of colourimetric detector tubes with appropriate pumps (eg Drager pump and ozone detector tubes, Kitagawa pump and ozone detector tubes).

While the use of one of these tubes will only give an ‘instantaneous’ reading (over the several minutes of drawing air through the tube), a detection limit of around 0.025 ppm may be obtainable. The use of these pumps and the reading of colour change on the tube with direct reference to concentration of ozone in air makes this a relatively easy system to use.

### Controls

Initially a logical question to ask is, ‘Are there safer substitutes to use for sanitising?’ or indeed, ‘Is the use of ozone of any proven or substantial benefit at all?’

These are questions that need to be answered by the wine industry itself.

While the author has only been involved in monitoring occupational exposures to ozone during trials of wine barrel cleaning on one occasion, over an hour or two, the following dot points are pertinent to minimising exposure to ozone:

- ensuring that adequate instruction and knowledge regarding the operation of the ozone generator, and control of the concentration of ozone in water is provided. Excessive ozone generation increases the exposure risks and may have other undesirable effects on the barrels.
- ensuring that the set-up (of both ozone generator and barrel) minimises the potential for escape of ozone gas as well as ozone-bearing water mist. The health hazards of this mist must not be underestimated.
- ensuring adequate ventilation (eg. outside) to dilute any ozone generated as rapidly as possible.
- ensure that equipment/hoses are in good condition and tightly fitted to prevent accidental spraying of operators.
- ensure that equipment/hoses are resistant to degradation by the ozone. Hoses should be regularly inspected for condition. Rubber is not recommended.
- eye protection (visor or at least safety glasses) and impervious gloves should be worn.
- respiratory protection (half-face respirator with organic vapour cartridges) should be on hand. Check with your safety equipment supplier.
- If monitoring with a direct reading meter, check for those issues alluded to earlier in this presentation.
- ensure electrical safety and appropriate condition of leads and plugs, due to the presence of water.

### References