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Technical Bulletin

2024

Respiratory Protection for Ozone

Background

Ozone is a colourless to pale blue gas with a pungent odour. Naturally occurring in the Earth's atmosphere, ozone is a powerful oxidant and is used in chemical synthesis; commercially as an oxidant; for purifying or treating air, drinking water and industrial waste; in the manufacture of, oils, bleaching, waxes and other chemicals[1] . It is also present in some arc welding applications. It can cause irritation to the eyes, nose and throat, and at higher concentrations can lead to headache, upset stomach, shortness of breath and lung damage[2] ,[3] .

In Europe, EN 14387:2021 specifies performance requirements and test methods for various types of respiratory gas and vapour filters. Ozone is not a standard test gas specified in this standard. However, EN 14387 also sets out the requirements and suggested test method for "Filter Type SX", i.e., "for use against specific gases and vapours as specified by the manufacturer". The suggested sorption test gas concentration of 0.5% (5000ppm) could be deemed excessive, unrealistic, and potentially dangerous to test lab personnel. For reference the UK Occupational Exposure Limit, OEL is 0.2ppm (15min STEL)[4] , and according to NIOSH Ozone has Immediately Dangerous to Life and Health (IDLH) concentration limit of 5ppm[5] . In the US, NIOSH does not have a test method or respirator approval for ozone. Previous research has shown the ability of a disposable particulate respirator with a thin layer of carbon to filter 1 ppm ozone for up to 8 hours at flowrates of 64 liters/min[6] . Although ozone is an oxidizer, Johnston et al., did not find any oxidation effects during their tests.

This technical data bulletin describes testing of reusable respirator and powered air purifying respirator (PAPR) filters and cartridges against ozone. The resulting data may also be used to help determine a change schedule for respirator filters and cartridges used against ozone.

Method

Occupational exposure limits (OELs) for ozone vary by country or region. The US OSHA 8-hour time weighted average limit for ozone and the NIOSH ceiling limit is 0.1 ppm. Therefore, service life testing was done at approximately 1 ppm ozone (10 times the OEL). Pure oxygen was passed through a mass flow controller (Brooks Model GC-100CXXC) to an ozone generator (Oxidation Technologies HTU-500). This was mixed with humidified air and then passed through the respirator cartridge/filter. The sample stream was plumbed using fluorinated ethylene propylene tubing to ensure that the ozone did not react with the tube surface. Reusable respirator cartridges and filters were tested at approximately 64 L/min which is the test flow used by NIOSH for gas/vapor cartridges. This flow rate also corresponds to breathing during heavy work[7] . PAPR cartridges were tested at flow rates similar to the PAPRs in use (between 170 - 200 L/min). Humidity was controlled to approximately 30%, 50% or 70% RH using a 3M propriety controller. Both the cartridge challenge and exit concentration were monitored with ozone detectors (2B Technologies 106-L) which have a 3 part per billion (ppb) limit of detection and accuracy of 1.5 ppb or 2% of the reading, whichever is greater.

1. https://www.cdc.gov/niosh/topics/ozone/
2. https://gestis-database.dguv.de/data?name=004040
3. Oxford Handbook of Occupational Health, 2nd Edition.
4. https://www.hse.gov.uk/pubns/priced/eh40.pdf
5. https://www.cdc.gov/niosh/idlh/10028156.html
6. "Ozone Removal Capability of a Welding Fume Respirator Containing Activated Charcoal." A.R. Johnston, J.F Dyrud and Y.T. Shih. American Industrial Hygiene Association Journal, 50:451-454 (1989).
7. "Respirator Cartridge Efficiency Studies VIII. Summary and Conclusions." G.O. Nelson and A.N Correia. American Industrial Hygiene Association Journal, 36:514-525 (1976).

Results/Recommendations

The following 3M products are 3M recommended for use against up to 1 ppm ozone with an estimated service life of up to 40 hours:

- 3M™ Adflo™ Organic Vapor/Acid Gas Cartridges, 15-0499-99
- 3M™ Adflo™ Gas Filter A2, 837542
- 3M™ Adflo™ Gas Filter A1B1E1, 837242
- 3M™ Versaflo™ Organic Vapor/HEPA Cartridge TR-6510N / 37361 (AAD)
- 3M™ Particulate Filter 2078, P95, with Nuisance Level Organic Vapor/Acid Gas Relief
- 3M™ Secure Click™ Particulate Filter P95 with Nuisance Level Organic Vapor/Acid Gas Relief D3078
- 3M™ Secure Click™ Organic Vapor Cartridge D8001
- 3M™ Secure Click™ Filter A1, with Dual Flow, D8051
- 3M™ Organic Vapor Cartridge 6001
- 3M™ A1 Gas and Vapour Filter 6051
- 3M™ A2 Gas and Vapour Filter 6055

The following 3M products are 3M recommended for use against up to 1 ppm ozone with an estimated service life of up to 8 hours:

- 3M™ Particulate Filter 2097/07184(AAD), P100, with Nuisance Level Organic Vapor Relief
- 3M™ Advanced Particulate Filter 2297, P100, with Nuisance Level Organic Vapor Relief
- 3M™ Secure Click™ Particulate Filter P100 with Nuisance Level Organic Vapor Relief D3097

The following cartridges or filters are not recommended for hazardous levels of ozone, but may instead be used for nuisance odor relief:

- 3M™ Adflo™ Powered Air Purifying Respirator Nuisance Odor Pad Assembly 35-0699-99
- 3M™ Adflo™ Odour Filter, 837110
- 3M™ Versaflo™ HEPA & Nuisance OV Filter TR-6820N/37360(AAD)
- 3M™ Hydrogen Fluoride Cartridge/Filter 7093C, P100, with Nuisance Level Organic Vapor and Acid Gas Relief
- 3M™ Particulate Filter 6038 P3 HF, with Nuisance Level Organic Vapour/Acid Gas Relief
- 3M™ Secure Click™ Hard Case P100 Particulate Filter D9093C, with Nuisance Level Acid Gas Relief
- 3M™ Secure Click™ Hard Case P3 R Particulate Filter, Hydrogen Fluoride and Nuisance Level Organic Vapour and Acid Gas Relief, D9038

To investigate any potential oxidation effects, cartridges and filters were tested at approximately 10 ppm at 70% RH for 4 hours. No noticeable increase in temperature was observed in the air stream nor any physical markings on the outside of the cartridge or filter due to the removal of ozone.

Conclusion

Certain 3M reusable respirator and PAPR organic vapor cartridges may be used to filter ozone up to 1 ppm. Adflo organic vapor/acid gas cartridges may also be used to filter ozone up to 1 ppm. Service life was >40 hours with no significant ozone detected. 3M reusable respirator and PAPR particle filters with a thin layer of carbon for “nuisance organic vapors” had variable performance and must be considered individually. No noticeable oxidation reaction (e.g. increased temperature) was noticed as a result of filtering 10 ppm ozone. Until further study is done, supplied air respirators are suggested for ozone concentrations > 1 ppm.

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3M PSD products are occupational use only.

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