

Decontamination of Reusable Breathing Apparatus

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A mechanical **decontaminator** has been installed at each of the four rescue stations in New South Wales, Australia, to address the issue of how to prevent the spread of infectious disease in reusable breathing apparatus components and at the same time provide an effective training program. These machines are especially designed to ensure the complete removal of saliva and other soil from corrugated breathing tubes and other breathing apparatus components.

Introduction

Wearing a breathing apparatus, such as the Draeger Model BG174, generates a considerable volume of saliva that covers the insides of the face-mask or mouthpiece, breathing bags, and corrugated breathing tubes. With widespread concerns over the spread of infectious organisms such as hepatitis B, herpes, and acquired immune deficiency syndrome (AIDS), the immediate problem facing the various industries that use breathing apparatus is the provision of adequate and **effective** training while protecting trainers and wearers from contracting these diseases.

A strict code of practice for cleaning and disinfecting is essential. The procedure adopted must

ensure the complete destruction or removal of bacteria, fungi, and viruses that may be present in the saliva of wearers.

The Southern Mines Rescue Station is typical of a New South Wales Station with 300 trainees and 180 sets of closed-circuit breathing apparatus. Two to three brigades of between five and eight men train daily, five days per week. On intercolliery competition days, up to 80 sets of apparatus may be worn in a single day, and in a protracted emergency over 150 sets have been used. Manual cleaning can lose its **effectiveness** in times of high usage. This can result from **shortcutting** the process to finish on time and from overusing wetting and disinfecting liquids.

Microbiology

Many inquiries from users of reusable breathing apparatus **have** been received about the potential for transmission of hepatitis B (HBV), the AIDS virus (HIV), the herpes viruses, and various upper and lower respiratory infections including influenza, infectious mononucleosis, and tuberculosis. The transmission of HBV and the herpes simplex viruses by saliva is well known (Zamel, 1988) and, although there is no positive evidence of the transmission of HIV by this route (AIDS Task Force, 1984), it is difficult to convince breathing apparatus wearers of this.

Most viruses unprotected by blood or tissue are destroyed by temperatures in the range of 65 to 100°C as well as by commonly used chemical disinfectants such as alcohols, phenols, and aldehydes (Zamel, 1988). The hepatitis B virus exhibits a resistance to heat and requires temperatures approaching boiling point for its destruction. Because many breathing apparatus components cannot be subjected to these temperatures, chemical disinfection is preferred. Exposure for 10 minutes to a 2% **glutaraldehyde** solution at room temperature will destroy the HBV virus as well as the AIDS virus and the herpes simplex types 1 and 2 viruses.

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Disinfection

Sterilization is defined as the use of some form of chemical or physical method to destroy all microbial life, including highly resistant bacterial endospores (Favero, 1985). *Disinfection* is defined as a process that inactivates nearly all pathogenic microorganisms but not all microbial forms (bacterial endospores) (Favero, 1985). Breathing apparatus components make contact with the mucous membrane without penetration, so are classified as semi-critical as a transmission source and therefore do not require sterilization prior to reuse (Zamel, 1988).

The prerequisite for effective disinfection is the meticulous, thorough cleaning of components prior to treatment to remove all saliva or soil in those components destined for reuse. If not, contamination in the presence of retained fluid and exposed heat is potentially a source of microbial overgrowth and transmissible disease. The cleaning is usually performed by water with a detergent additive and is designed to remove rather than destroy the microorganisms. Disinfection of breathing apparatus components is then best achieved with the use of a suitable chemical disinfectant such as a 2% glutaraldehyde solution.

Chemical Disinfectants

The formulation registered by both the Environmental Protection Agency in the United States and the New South Wales Health Department for high-level disinfection of respiratory-protective devices is an aqueous solution containing 2% glutaraldehyde with a pH of 6.3–6.5. In the product known as **Wavicide 01** or **Sonacide**, the **glutaraldehyde** has been complexed by hydrogen bonding to a glycol to produce a stable, almost odour free formulation (Whiteley Chemicals, 1985). Alternative accepted glutaraldehyde formulations include **Cidex 7**, a 2% alkaline solution; **Glutarex**, a 2% neutral solution; and **Sporicidin**, a 2% alkaline solution with a phenolic buffer (Brnich, 1989).

Alternative disinfectants to glutaraldehyde include sodium **hypochlorite** (household bleach) diluted with water 1:5 to 1:100, 9% **o-phenylphenol** (**Dentaseptic**) and 1% **o-benzyl-p-chlorophenol** (**Multicide**) (Brnich 1989).

Mechanical Decontamination

In the last ten years a number of mechanical devices have been developed to process the disinfection of respiratory equipment. Many of the earlier mechanical devices were not effective because the circular positioning of the breathing tubes could not allow for the complete removal of all contained fluids at the end of the washing, rinsing, and disinfection cycles, and these retained fluids rendered total drying unlikely (Zamel, 1988).

A series of **decontaminators** has been designed in Australia to overcome these shortcomings, particularly in the wetting, disinfecting, and drying of corrugated breathing tubes. The largest of these machines is shown in Figures 1 and 2 and can accommodate up to eight sets of facemasks or mouthpieces, corrugated breathing tubes, and breathing bags. It incorporates a water jet system so arranged that the breathing tubes are treated in the vertical position.

The jet system ensures a **waterflow** to surge in a hollow cone configuration through the corrugations in a cascading manner, as shown in Figure 3, ensuring complete removal of contaminated material. Ten litres of water pass through each breathing hose for each minute of the wash and disinfection cycles, ensuring the complete elimination of contaminants. A fault security **system** also warns if water is retained within the machine at the conclusion of any cycle; this prevents recirculation of possibly contaminated water.

The smaller **decontaminator**, shown in Figure 4, is designed for the facemasks of open-circuit breathing apparatus or the mouthpieces of training self-rescuers when corrugated breathing tubes are not involved. An ancillary basket will then accommodate other components such as exhalation valves and speech diaphragms that have been exposed to exhaled breath or saliva.

The following automatic process of disinfection will occur after a drying time (0–240 minutes) has been entered and the start button has been pushed:

1. A pre-wash cycle for two minutes with cold water.

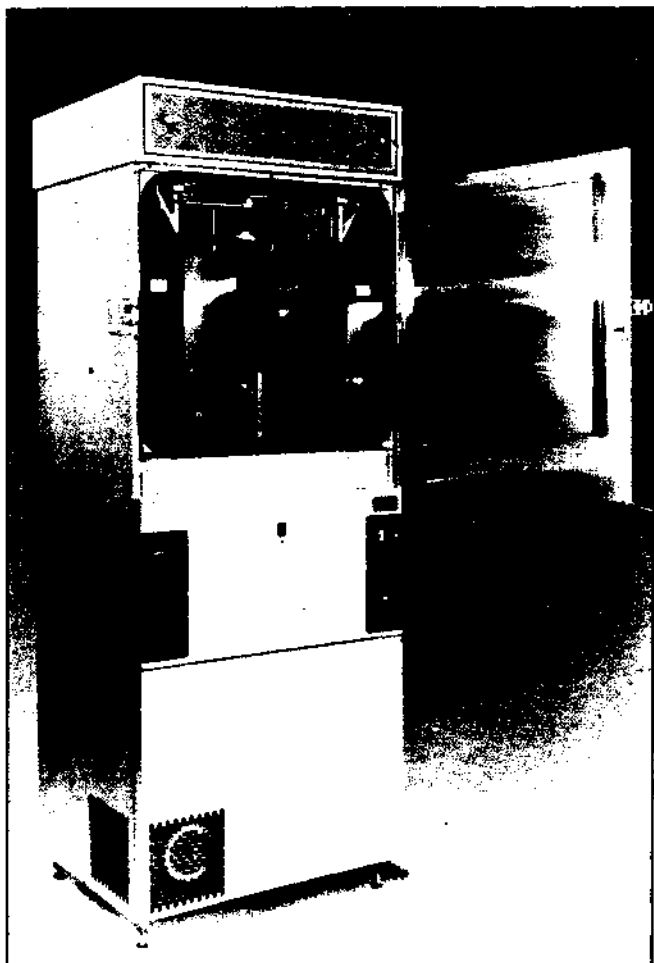


Figure 1. The Zexa AAD series decontaminator model 200.

2. A **wash/rinse** cycle of five minutes with water heated to 60°C circulating at 240 litres per minute. During this period a fixed amount of low foaming detergent is automatically dispensed into the circulating water to **wet** the internal and external surfaces of the components.

3. A hot rinse cycle of 1.5 minutes.

4. A disinfection cycle of 10 minutes where a measured amount of chemical disinfectant is circulated internally and externally around the apparatus components at a rate of 240 litres per minute. At the end of this cycle, the chemical is pumped to a rear tank for reuse.

5. Three rinse cycles to remove the last traces of chemical.

6. A drying cycle of up to 240 minutes to ensure complete internal and external drying of all apparatus components.

A series of pumps and solenoid valves ensures the complete removal of all wash and rinse fluids between cycles. A fault code security system ensures the **decontaminator** is functioning correctly through each sequence, thus **ensuring** that improperly cleaned components are not reused.

Conclusion

The New South Wales Mines Rescue Service has overcome the potential problems from manually cleaned breathing apparatus by installing specially designed mechanical **decontaminators**. These decontaminators provide a highly efficient and safe

means of cleaning, disinfecting, and drying breathing apparatus components. This is not only labour saving but eliminates the possibility of **transmitting** infection and disease in apparatus components destined for reuse.

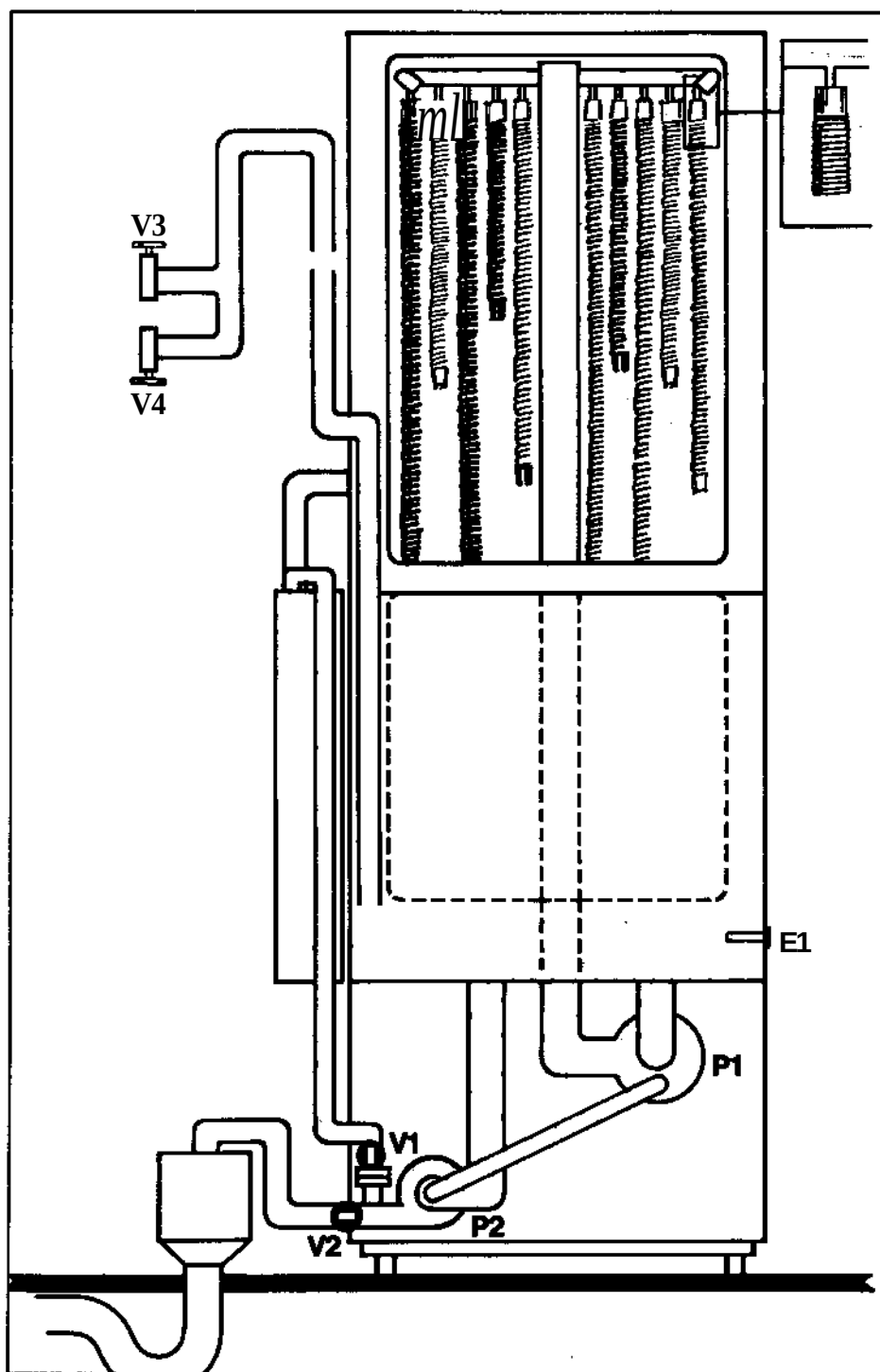


Figure 2. Schematic diagram of the chemical operation of the Zexa AAD series decontaminator.

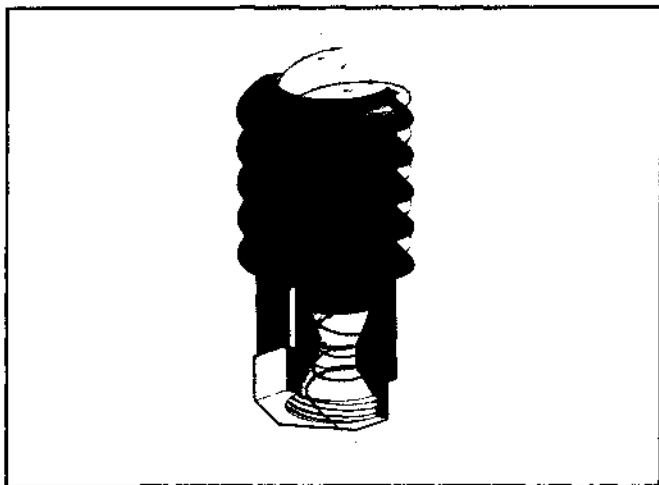


Figure 3. Turbulence through a corrugated tube.

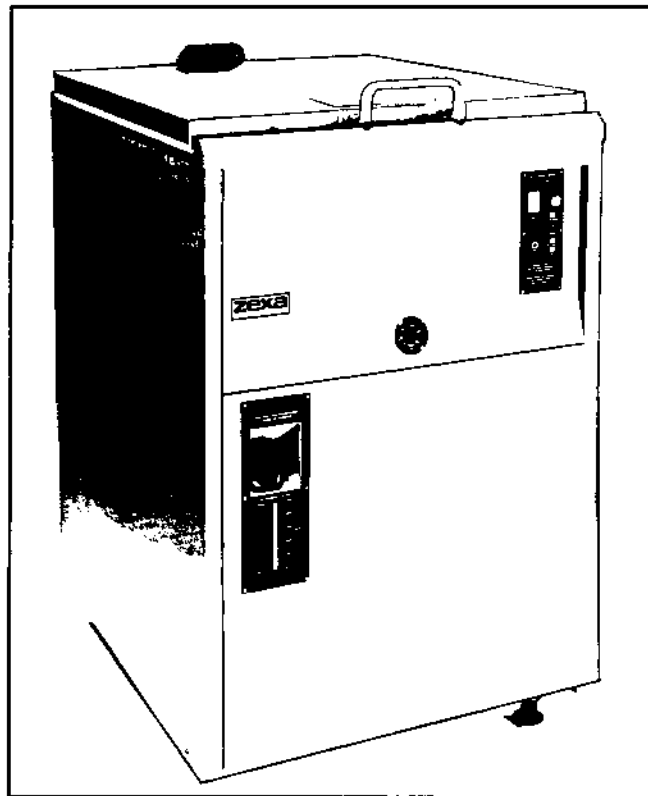


Figure 4. The Zexa AAD series decontaminator model 280.

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