

Annex A. Non-chemical warfare human studies

A1. Introduction

Over the period covered by the survey Porton conducted human studies with Service volunteers which were not strictly relevant to chemical warfare. These studies can be separated into three categories, according to the sphere in which they had relevance.

- Military The Services have used from time to time smokes to screen movements of forces from the enemy. The effects of inhaling screening smokes were investigated in animal and human studies. Some smokes were used by the Services in fire-fighting training. In the 1940s and the 1950s insecticides were used to protect the Armed Forces (particularly from locusts) when they operated in some theatres overseas. Human studies assessed the irritancy of insecticides. Human studies were also conducted to assess the hazard of handling rocket fuel, the fumes given off when batteries were charged in submarines and the effects of hydrogen chloride when used as a propellant.
- Occupational Two forms of occupational hazards were investigated at the behest of external authorities: the hazards to men cleaning underground petrol storage tanks and the hazard to pilots flying jet aircraft in which the cabin atmosphere was pressurised. Four other studies appear to have addressed occupational hazards from methyl bromide, hydrofluoric acid and caustic soda.
- Civilian A great deal of work was conducted into the effects of London smog which caused the deaths of 60 people in December 1962. Deaths from respiratory diseases increased to 5.7 times their normal level during the London fog of 1952; the Lancet in 1924 noted that London smog increased mortality considerably when present at low air temperatures. Porton work with animals and humans considered the effect of constituents of London smog in mid-to-late 1950s. The hazardous effects of black smoke and diesel fumes were investigated but only in animal work¹. Some work appears to have been conducted with alcohol on behalf of the Home Office's forensic science laboratory at Aldermaston.

A2. Military Hazards

A2.1 Smokes

In 1974 animal studies had been conducted with a smoke called PN826 which was the preferred smoke for anti-ambush purposes required by the Army. Animals exposed to PN826 in a single exposure of 600 mg/m³ for 30 minutes, and those exposed daily for 5 days to 500 mg/m³ for an hour, demonstrated no lesions in the respiratory tract². A field trial was proposed wherein men would walk through a cloud of PN826 smoke generated by a grenade. COSHE decided that more animal work was necessary, and in November 1974 approved short exposures of up to 200 mg/m³ for 2 minutes in human studies³.

By April 1975 eight men had been exposed under those conditions. They experienced minor irritation to the throat and some stinging of the eyes but these symptoms disappeared in 3-4 minutes. Sputum samples were taken to find out if the men retained particles from the

¹ WO189/963 Porton Technical Paper 645. The acute toxic effects of some black smokes 5 Jun 58. WO189/1029 Porton Technical Paper 714 Causes of death in mice after non-toxic dosages of smoke 15 Feb 60. WO189/861 Porton Technical Paper 535 The toxic action of fumes from a diesel engine under four different running conditions. 14 Feb 56.

² COSHE 95th meeting 30 Sep 74.

³ COSHE 96th meeting 18 Nov 74.

smoke. No particles were detected one hour after exposure⁴. No further human studies with PN826 were conducted.

In 1974 the RN were also interested in using a smoke for fire fighting practice in confined spaces. Cinnamic acid smoke was considered as a possibility; it was already used in a grenade. Animal studies revealed⁵:

- at single exposures of 27,600 mg/m³ (t = 30 minutes) and 73,350 mg/m³ (t = 45 minutes), no untoward effects were observed over the 14 days after exposure and no abnormalities were found at autopsy;
- with repeated daily exposures of one hour over 5 days (cumulative exposure 198,000 mg/m³) no deaths occurred and no abnormalities were found at autopsy.

After reviewing these results COSHE approved human studies in November 1974. The exposure to be used was set at a higher level than would be expected in a typical submarine engine compartment. In that situation men might be exposed to 75 mg/m³ for 10 minutes but the study used a maximum exposure period of 30 minutes to guard against unusual conditions⁶. Initially, though, the exposure should be limited to 750 mg/m³.

By October 1975 five volunteers had been exposed to 75 mg/m³ for 10 minutes. Respiratory functions were monitored but the smoke was found to be quite dense and the experimental staff (who wore respirators) in the chamber with the volunteers found that their speech was not easily understood by the volunteers⁷. Further tests were conducted with a few more volunteers in which the experimental staff wore throat microphones to improve speech clarity. The work was completed by December 1975, and no effect on the respiratory and cardiovascular systems had been found⁸.

However, cinnamic acid smoke was evidently not adopted by the RN for fire fighting practice after this work in 1975. In 1986 the possibility arose of cinnamic acid smoke replacing the oil-based smoke then in use; this was discussed by the MC which commissioned further work with animals⁹. Animal work concentrated on exploring the effects of repeated doses daily over the course of 50 days. The work concluded that the "no effects" concentration of cinnamic acid smoke for repeated exposures could be taken as 30 mg/m³: about a third of the concentration that would be expected if the smoke were used for fire fighting training. Further, as the exposure experienced by men in fire practice drills was likely to be far less frequent than the exposure regime used in the animal work, it was concluded that the smoke was a satisfactory and relatively safe fire simulant¹⁰.

In 1987¹¹ 15 volunteers took part in a study of the effects of inhaling cinnamic acid smoke each being exposed to 13 mg/m³ for 10 minutes. No significant changes were measured in lung function. One subject developed transient "alveolar shadowing" but he was clinically well and his lung function was unaffected¹². No further human studies with cinnamic acid smoke were carried out in the remainder of the period covered by the survey.

A2.2 Fuel

In 1946 and 1947 a study was conducted to explore the irritancy of the rocket fuel C-Stoff. Many cases of skin irritation from C-Stoff had been reported in Germany and cases of

⁴ COSHE 99th meeting 14 Apr 75.

⁵ COSHE proceedings. Inhalation toxicity of cinnamic acid smokes. Med/IT4010/2743/74 7 Nov 74.

⁶ COSHE 96th meeting 18 Nov 74.

⁷ COSHE 103rd meeting 27 Oct 75.

⁸ COSHE 104th meeting 8 Dec 75.

⁹ MC meeting 6 Nov 86.

¹⁰ Technical Paper 482. Repeated dose inhalation toxicity of cinnamic acid smoke (PN868). Jul 87 [UK R].

¹¹ Experimental Log MPG 100.

¹² Annual Establishment Report: 1988 review. 5 May 88 [S UKEB].

dermatitis of the hands, of mild to moderate severity, had arisen in workers at RAE Farnborough. C-Stoff was composed of 30% hydrazine hydrate and 57% methanol in water. A study was conducted to investigate the irritancy of C-Stoff (in two slightly different forms) and of 30% hydrazine hydrate in water. The study also considered ways in which any irritancy could be treated¹³. The effect on the eyes was explored in animals; volunteers took part only in skin irritancy tests.

The first phase involved solutions applied daily for 14 days as 2 mm diameter drops on the nailfolds and forearms of 2 volunteers. At the end of the 14 days erythema and stinging were experienced but passed off in the next few days.

The second phase used a different method of contamination. Men immersed one hand to the level of the knuckle twice daily for 10-16 days. Some of the tests in this phase considered forms of treatment, either different ways of decontaminating the skin after immersion or using a barrier cream as a prophylactic before immersion. Twenty four men took part in the treatment tests.

The final phase reverted to using the forearm to test the prophylactic value of lanoline, Vaseline and collodian film. A 3 mm diameter drop of C-Stoff was applied to the treated site of the forearm twice daily for 11 days. Twenty three men took part in this phase. The study concluded that C-Stoff was a mild to moderate skin irritant, but the effects could be mitigated by applying either lanoline or Vaseline to the hands before working with the material.

A2.3. Submarine batteries

Submarines in operation with the RN in the 1950s periodically had their batteries charged while at sea. Charging gave off a substance called stibine (antimony hydride) which might prove to be a hazard. A trial of battery charging was conducted on HMS Artful in August 1960 in which 11 volunteers were exposed to an atmosphere containing 0.3 ppm of stibine for 9 hours¹⁴. Blood and urine samples taken from the volunteers showed no evidence of stibine intoxication.

A second battery charging trial was carried out on HMS Porpoise at Portsmouth in July 1961. After the normal period of battery charging (9 hours) the submarine was closed for another 8 hours and the concentration of stibine measured. During these 17 hours guinea pigs and mice were placed at various sites in the submarine and were then returned to Porton for analysis. Nine volunteers also participated and samples of their blood and urine were taken to Porton for analysis. Examination of these samples and the animals failed to show any injurious effects¹⁵. The peak concentration of stibine measured during battery charging was 1 ppm.

No record has been found in the experimental logs to suggest that the volunteers who took part in these trials were Service volunteers recruited under the normal observer scheme. No mention has been found of Service volunteers attending Porton at that time being transported to HMS Artful or to HMS Porpoise in the months in question. This, and the fact that samples only were brought to Porton for analysis, suggests the volunteers were recruited from the boats' companies.

A2.4. Insecticides

The first human study with an insecticide during the period covered by the survey was carried out in May 1943, to investigate the irritancy of a German insecticide called "Neocid"¹⁶. A small piece of lint was dampened with a 0.1% solution of Neocid in kerosene and placed on the arm of a volunteer and held in place with Elastoplast for 2 hours. Skin reactions were

¹³ **WO189/286** Porton Technical Paper 22. The irritancy of hydrazine hydrate ("C-Stoff") to skin and eyes. 1 Sep 47.

¹⁴ **Annual report July 1960 to June 1961 [S]**.

¹⁵ **Annual report July 1961 to June 1962 [S]**.

¹⁶ **Experimental Log MPG 58**.

noted over the succeeding day. As the study progressed volunteers wore a piece of lint for 24 hours and finally some volunteers had a piece of lint applied daily to their arm over 4 successive days. 34 volunteers took part in the work.

DDT and DNOC (Di-Nitro-ortho-cresol) were insecticides to combat lice and locusts investigated for use with the Services from 1943 to 1955. The first tests in October 1943 examined whether flannel shirts impregnated with DDT caused any skin irritation. A piece of a shirt was placed in contact with the arm of a volunteer and left in place for 24 hours. Some volunteers had pieces placed on their arm daily over 3 successive days¹⁷. Twelve volunteers took part in these tests.

The bulk of the remaining tests involved about 300 volunteers wearing impregnated clothing. Vests impregnated with DDT were worn for periods of up to 40 weeks in a series of trials spanning 1944 to 1952. These tests were successful in that very little irritation occurred and the vests retained a good proportion of the DDT (40% being one example cited) initially impregnated into the garment¹⁸. Tests of Army Angola shirts impregnated with DDT were conducted in 1947 but proved disappointing as the method of fixing DDT in place was found wanting¹⁹.

Studies in the period from 1945 to 1948²⁰ explored the irritancy of DNOC and an insecticide called "666"; these are summarised below.

- The first studies of skin irritancy carried out in 1945 and 1946 were similar in form: a small amount of powder (0.25 - 1g) was placed on, or dusted onto, the forearm skin, left for 24 hours, sealed with cellophane under elastoplast. In some tests solutions of the insecticides were either sprayed onto the skin, or pieces of lint were dampened and placed on the forearm. Twenty four volunteers took part in the study with 666 insecticide and 16 in the DNOC study.
- A short study was carried out in February 1946 of the irritancy of 666 insecticide smoke which was often disseminated by means of a generator. Six volunteers took part. 666 smoke was released in the chamber and, after mixing, 3 volunteers entered. They remained for 90 seconds: nausea developed quickly together with coughing, lachrymation and irritation to the throat. The smoke was then cleared to "moderate" levels and another 3 volunteers entered the chamber. They stayed for 2 minutes and experienced some tingling in the throat and coughed but did not feel nauseous. After the smoke had been cleared away the original 3 volunteers re-entered the chamber and stayed for 5 minutes. They experienced slight irritation to the throat.
- A study of the effect of repeated applications of DNOC to the skin was carried out in February 1948. The first series of tests saw 14 volunteers having 7 - 140 mg of DNOC applied on their backs over an area of 4.5 by 15 cm, with applications daily for 4 or 5 days. No skin reaction was noted, and a further 10 volunteers had up to 280 mg of DNOC applied to their back, in two applications only. They experienced no reaction.
- The second part of the DNOC study in February 1948 involved 9 volunteers having a solution of DNOC (of 1 part in 10 in water) applied to their arms in a similar tests to those done previously. Seven volunteers had 5 cc of DNOC solution painted on to their buttocks and posterior thighs with applications repeated 3 times a day for 3 or 4 days. No reaction was noted. Three men then had DNOC (1.75% solution in acetone) applied to three areas of their back and chest, again with no reaction recorded.

¹⁷ *ibid* (16).

¹⁸ **Porton Progress Report 16. October to December 1950 [S].**

¹⁹ **Porton Progress Report 2. Progress for the quarter ending 30 Jun 47 [S].**

²⁰ **Experimental Log MPG 59.**

Further studies in 1954 and 1955²¹ considered the irritancy of insecticides on the skin using the method of placing a small amount on the forearm either as a powder or as solution on lint. About 30 volunteers took part in these studies. No further studies with insecticides were conducted.

A2.5. Hydrogen chloride vapour

A study was carried out in 1965 of the effects of hydrogen chloride vapour. It is not certain why the study was performed as no report of the work has been found but the experimental log which contains the details of the work refers to hydrogen chloride as a propellant²². On the assumption that the propellant was used in military equipment the description of the work is placed here.

Over the course of June and July 1965 twenty nine volunteers were exposed to hydrogen chloride vapour at a concentration of 700 parts per million for 30 seconds. Seven volunteers were exposed three times over the course of 5 days. A further 6 volunteers underwent the same exposure in September 1965. The experimental log records that there were "no complaints" from any of the volunteers who took part.

A3. Occupational Hazards

A3.1. Petrol tanks

In the mid 1940s some casualties occurred in men employed to clean, seal and repair underground steel petrol tanks. The Petroleum Board approached Porton for help in finding the source of toxic material and ways in which the hazard could be overcome. The request prompted a study which is described below²³.

- To begin with Porton inspected a tank prepared for cleaning. The tank was emptied of petrol but amounts of sludge and water remained on the bottom surface of the tank. Samples of these were taken for analysis.
- It was impracticable to rid the petrol tanks of the sludge. Animal work was conducted to explore the toxicity of the sludge and of tetra-ethyl lead (a constituent of the sludge and also found in the water residue).
- Porton considered various means of rendering the sludge safer by chemical treatment. One option was using sulphur dioxide which was readily available and easy to use. It would react with the sludge to produce diethyl lead sulphite (DELS). DELS was less soluble and less volatile than the sludge and thus reduced the skin contact and inhalation hazard.

Animal work explored the toxicity of DELS. Two volunteers took part in human tests to consider its vesicancy. 1 g of DELS in 1 cc of propylene glycol was applied as paste on white lint to a 2 inch square area on the forearm. The lint was covered with cellophane and bandaged for 24 hours. One volunteer had the lint applied to normal skin, the other to old scar tissue. Vesication was induced in both volunteers, which had not quite healed 21 days afterward although a solution of penicillin was applied daily to the affected sites.

The report concluded that treating the sludge with sulphur dioxide was no solution. However, Porton noted that if the full precautions laid down by the authorities were followed no casualties would have occurred in men working on petrol storage tanks. As among "relatively low grade labour and supervision, lapses of safety discipline are inevitable" Porton suggested using specialist workers.

²¹ **Experimental Log MPG 61.**

²² **Experimental Log MPG 64.**

²³ WO189/290 Porton Technical Paper 26. Lead tetra-ethyl hazard to personnel cleaning petrol storage tanks. 6 Oct 47.

A3.2. Pressurised jet aircraft

In the 1950s cabin pressurisation in jet aircraft was obtained by bleeding off a small part of the air delivered by the engine compressor. That air might contain a small quantity of lubricating oil which might be decomposed (pyrolised) at the operating temperature of the compressor. Among the decomposition products could be irritating products such as aldehydes.

In 1955 complaints of illness of pilots in the US flying pressurised jet aircraft were investigated (in the US) and Porton investigated the effect of exposure to vapours from engine oils in animal work in the same year. This work and subsequent evaluations are reported in a technical paper published in 1960²⁴. The details of the work are given below.

- Four oils were considered in the animal work of 1955 which found that a 6 hour exposure to a concentration of about 1.6 mg/m³ had only a transient effect on several animal species. The vapour used in this work was produced by heating the oil to a temperature of 300°C.
- In 1955 volunteers were exposed to a concentration of the same oils of 0.16 gm/m³. Each of the four oils tested had "no effect on observers that would have interfered with normal efficiency."
- In 1958 a request was received to re-examine the oils at temperatures of 500-600°C as they were being used at these temperatures in engines with higher pressure ratio engines. Further animal work was carried out, as was a study with volunteers.

Five volunteers took part in tests with the four oils originally studied in 1955 but with vapour generated at the higher temperatures. Advice from engine manufacturers suggested that the probable maximum limit of contamination in cabin air was 0.2 mg/l. This advice was used in the design of the human tests:

- initially the chamber containing an atmosphere with a concentration of the oil being tested at 0.05 mg/l;
- this concentration was maintained to see if the volunteers experienced any effect and, if not, the concentration was increased to 0.1 mg/l;
- volunteers then left the chamber for a rest while the concentration was increased to 0.15 mg/l and re-entered and remained for 30 seconds;
- the volunteers left the chamber again, the concentration was raised to 0.2 mg/l and the volunteers re-entered and remained as long as they could for up to a maximum of 30 seconds.

With these 4 oils the volunteers experienced lachrymation which became intolerable after only a few seconds and it was concluded that an unmasked pilot would soon be unable to read instruments. However, newer oils were also tested in the laboratory and in animals. The constituents in their vapour was analysed and compared to the constituents in the vapour from the older 4 oils. From this analysis Porton concluded that pyrolised oil was not sufficient, at the highest concentration which seemed possible, to cause the pilot of a jet aircraft to lose control.

²⁴ WO189/1037 Porton Technical Paper 723. The acute inhalation toxicity of the products of pyrolysis of several synthetic lubricants. 19 Apr 60.

A3.3. Methyl Bromide

The skin effects of methyl bromide and methods to treat them were studied in May 1941 and in January 1947. The reason for these studies is not clear. Methyl bromide (also known as bromomethane) is a toxic gas, easily liquified, and has been used as a fumigant against insects and rodents and for soil. One of the experimental records covering May 1941 notes that methyl bromide was used in fire extinguishers²⁵. It is assumed, therefore, that methyl bromide was studied as an occupational hazard.

The study in May 1941 explored the effect of methyl bromide on skin and investigated the effectiveness of treating contamination by washing with soap and water or a solution of sodium bicarbonate²⁶.

- Five volunteers had a piece of lint (2 inches by 1 inch) dampened with methyl bromide strapped to their arm under elastoplast. The lint was kept in place for up to 3 days although two volunteers had their pieces removed after 10 hours and 17 hours because the methyl bromide caused vesication.
- Two volunteers tested the two forms of treatment. They had a piece of lint dampened with methyl bromide applied to each arm. The pieces were left in place for 15 minutes and then one treatment rendered to one arm and the other treatment applied to the other arm.

The study in January 1947 considered the effectiveness of BAL ointment against methyl bromide²⁷. BAL ointment had been explored initially to treat mustard gas burns (and is covered elsewhere in the report). Eight volunteers took part in the study which had two parts.

- Four volunteers had half inch diameter circles of white felt dampened with methyl bromide liquid placed on the skin of the forearm and kept in place by Elastoplast for 15 mins. The area of the skin used had been treated by BAL ointment 15 minutes before the felt pieces were applied.
- Four volunteers had sites on their arms exposed to methyl bromide vapour (from a tube) for 15 minutes. The sites were treated with BAL ointment either 15 minutes before or 5 minutes after the application of the vapour.

The effectiveness of these treatments is not recorded. The experimental logs indicate that the volunteers experienced some erythema but no vesication after the various treatments had been applied.

A3.4. Hydrofluoric acid

Human studies with hydrofluoric acid (abbreviated to "HF" or "AHF") were conducted between August 1947 and December 1947 and in early 1949²⁸. Hydrofluoric acid is used for cleaning metals and etching glass. During World War II it was used in the manufacture and blending of aviation gasoline. Indeed, the reaction of the skin to a mixture of hydrofluoric acid and nitric acid was investigated in December 1941, in which 4 volunteers had a single drop (of either 0.5 mm or 0.75 mm diameter) placed on a forearm (they each reported the immediate onset of stinging and small burns subsequently developed)²⁹. Whether this work in December 1941 implies the interest in AHF arose because of its use in the production of aviation gasoline is debatable but the work carried out in 1947 and 1949 appears here on that assumption.

The work in 1947 and 1949 had three parts, outlined below.

²⁵ **Experimental Log MPG 27.**

²⁶ **Experimental Log MPG 54.**

²⁷ **Experimental Log MPG 59.**

²⁸ **Experimental Log MPG 59.**

²⁹ **Experimental Log MPG 56.**

- The effect of both AHF vapour and liquid was tested on 47 men. The amount of liquid AHF placed on the arm varied from 0.5 - 1.6g; either one drop or two drops were applied. Vapour was applied to two sites on the arm for 10 - 30 minutes.
- The effectiveness of various creams to decontaminate the skin from liquid AHF and to protect it from liquid vapour was tested on 42 men.
- Thirty four men took part in a test to find out if liquid AHF penetrated through gloves, nylon fabrics and other materials.

No report of the work has been found. The experimental logs indicate that some men experienced mild or severe erythema.

A3.5. Caustic Soda

Work was carried out in November 1947 to investigate the "physiological effect of 50% caustic soda on the skin"³⁰. No explanation for the work has been found but caustic soda was applied to the hands from which it might be inferred that the handling hazard was of concern. As caustic soda was widely used in industry, the study is described in this section of occupational hazards. Thirty volunteers took part in the work. Each had one 1 mm diameter drop of 50% caustic soda applied either to a tip of a finger or on the skin webbing between the first and second finger.

A.4. London smog

The nature of the toxic agent in London smog was not known in the mid 1950s. An HMSO report produced in 1931 found that in London fog the ratio of sulphuric acid to sulphur dioxide was much higher than the ratio in fog-free conditions³¹. Sulphuric acid mist was known to be more toxic to humans than sulphur dioxide and it had been suggested that the toxic effects of the mist could be prevented by neutralising the acid with ammonia gas. Animal work was conducted into the effect of sulphuric acid mist, ammonia and sulphur dioxide³².

A large human study was conducted to investigate the effects of smog constituents. Many volunteers took part although "a careful personal and family history relative to upper respiratory infections was obtained from each man."³³ Respiratory measurements were taken before and after exposure for each smog constituent. Blood pressure, pulse and breathing rates were measured before, during and after exposure. Some men had EEG measurements taken before and after. After exposure the men were examined routinely for three days. No volunteer was exposed more than twice and a period of at least 24 hours was allowed to elapse between exposures.

The exposures to sulphur dioxide are summarised in Table A.1. Exposures were achieved in the chamber (in the normal way) or by delivering the sulphur dioxide in a mask (similar to an oxygen mask in design). In some exposures ammonia was released or magnesium ribbon burnt to neutralise the sulphur dioxide.

³⁰ **Experimental Log MPG 59.**

³¹ WO189/782 Porton Technical Paper 450. The effects of a cold environment and of ammonia on the toxicity of sulphuric acid mist to guinea pigs. 11 Nov 54.

³² WO189/789 Porton Technical Paper 460 Pathological changes in guinea pigs exposed to sulphuric acid mist 24 Jan 55. WO189/851 Porton Technical Paper 525 Toxic effects of mixtures of sulphur dioxide and smoke with air 10 Feb 56.

³³ WO189/872 Porton Technical Paper 547. The effects of some possible smog constituents on human subjects. 19 Apr 56.

Exposure method	Concentration (mg/m ³)	Length of exposure (mins)	No. of men exposed
Mask	3.6 to 216	10	264
Chamber	2.7 to 62	60	330
Chamber (with ammonia released after 50 minutes)	26.4	60	10
Chamber (with magnesium ribbon burnt after 50 minutes)	16	60	10

Table A.1. Exposures to sulphur dioxide

Sulphur dioxide at exposure levels up to 800 mg.min/m³ induced little change either clinically or in lung function measurements. After exposures above 1330 mg.min/m³ lung resistance increased significantly above normal in half the volunteers exposed and lachrymation was a common symptom. In only 8 of the exposures were there significant changes in blood pressure, pulse or breathing rate. Ammonia and magnesium ribbon destroyed the irritant and broncho-restrictive effects of sulphur dioxide.

Exposures to sulphuric acid mist are summarised in Table A.2. The effect of particle size and humidity (which affects the acidity of the mist) was explored. In the first few months of this work exposures were conducted at levels of 41-1230 mg.min/m³ and no significant change in physiology from the normal was produced. Later exposures revealed that a sulphuric acid mist of larger particles and under high relative humidity were more irritant than a mist at the same concentration made up of smaller particles and stronger acidity (low relative humidity). For the former, intense coughing and lachrymation were almost intolerable at the outset of the exposure but men were able to continue in the atmosphere for 30 minutes. Again ammonia produced almost immediate relief from the symptoms but magnesium ribbon alleviated the effects only in men who stood close to it when it was burnt.

Exposure method	Concentration (mg/m ³)	Length of exposure (mins)	No. of men exposed
Mask (low humidity)	4.1 to 39	10	183
Chamber (low humidity)	2.9 to 39	60	316
Chamber (high humidity)	11.5 to 38	30 to 60	40
Chamber (with magnesium ribbon burnt after 20 minutes)	30	30	10
Chamber (with ammonia after 50 minutes)	2.9 to 39	60	356

Table A.2. Exposures to sulphuric acid mist

Some of the aldehydes produced by diesel engines were suspected of being present in London smog and the irritancy of some of these were tested in human studies³⁴. The exposures are summarised in Table A.3.

³⁴ *ibid* (PTP 547).

Substance	Concentration (mg/m ³)	Length of exposure (mins)	No. of men exposed
Formaldehyde	17.3	30	12
Acrolein	1.88	10	24
	2.8	5	
Crotonic aldehyde	12	15	12
Acetaldehyde	246	30	14
Propionic aldehyde	324	30	4
Butyric aldehyde	690	10	15
Iso-butyric aldehyde	620	30	15

Table A.3. Exposures to aldehydes

The first two aldehydes induced considerable irritation to the nose and the eye. Crotonic aldehyde produced lachrymation on average within 30 seconds. The others induced at most only mild irritation. Some men felt nauseous when exposed to iso-butyric aldehyde and one man vomited.

The study report emphasised that the exposures were relatively short compared to those expected in smog and were not repeated more than twice in healthy young men (most of whom were in excellent physical condition). Therefore drawing specific conclusions for the rest of the population was difficult. However, the results of this work suggested that sulphuric acid mist was the most important toxic substance in London smog.

A5. Alcohol

Alcohol

A study was conducted with alcohol to identify which psychomotor tasks could be relied upon to measure changes in performance induced by psychological incapacitating agents. That study is described in Annex E. Other trials were conducted with alcohol but their purpose is unclear. Experimental records show alcohol trials being carried out before 1965, for example in October 1961³⁵. The COSHE summary tables published in December 1963 contain an entry "Alcohol and Humour". The entry notes that a "Humour rating quiz" was to be administered to subjects 45 minutes after ingestion of alcohol with 1g/kg of alcohol being the highest dose and 0.5 g/kg the starting point. It is noted that:

"this test is now a standard procedure but alcohol had not yet been used with this quiz".

It is not clear if the phrase "standard procedure" refers to the use of the humour rating quiz or the use of alcohol. Possibly alcohol had been used before 1963 as some form of control in experiments. Alcohol trials continued after 1965 with entries in the experimental records for July and October 1967³⁶. Certainly many entries in experimental records are of the form "alcohol and quiz".

Human studies using alcohol continue into the 1970s. In June 1973 two volunteers refused to take part in alcohol trials because they didn't drink³⁷. Alcohol trials in the 1970s may have been for a different purpose to those conducted in the 1960s. Experimental records covering 1972³⁸ and 1977 respectively contain entries of "Blood alcohol trials" and "Alcohol blood and breathalysers trial". Some light on this work is cast by the minutes of the COSHE meeting held on 4 December 1975:

³⁵ Experimental Log MPG 63.

³⁶ Experimental Log MPG 66.

³⁷ Experimental log MPG 69.

³⁸ Experimental logs MPG 73 and MPG 74.

"Alcohol and blood: assistance given to CRE Aldermaston". CRE was a Home Office establishment, and COSHE noted that "it was difficult to justify the use of Service volunteers for Home Office work, but preliminary results are interesting to Porton from the point of view of therapy".

Porton's interest in alcohol is unclear; although the COSHE minutes imply that some work had already been carried out, the inference is that the work carried out in 1976 and 1977 with alcohol was connected with CRE. Perhaps the performance of men was being related to blood alcohol levels. This might identify the blood alcohol content which impaired performance. Identification of that content would help CRE design breathalysers so they were sensitive enough to detect blood alcohol concentrations.

Information which has survived indicates that this alcohol work involved volunteers driving on a private road after taking measured amounts of alcohol. As driving had, by the late 1970s, become one means of measuring performance (particular before and after taking some of the treatments developed for nerve agent poisoning) it might be inferred that Porton were helping the Home Office link the level of alcohol intake to the degradation in driving performance.