Ministry of Defence

Air Command Secretariat
Spitfire Block
Headquarters Air Command
Royal Air Force
High Wycombe
Buckinghamshire
HP14 4UE

Ref. 2016/7938

[redacted]

9 September 2016

Dear [redacted],

Thank you for your email of 20 August 2016 asking for a copy of a report on Sea King helicopters and details of monitoring carried out by the RAF. Specifically, you asked for:

1. ..... a copy of Report No: IofH/13/99 - A report on a preliminary survey to assess aircrew exposure to Sea King helicopter exhaust dated Mar 15.

2. The baseline and monitoring policy, schedule and details of any personal monitoring that was carried out by the Royal Air Force specific to the Sea King Search and Rescue helicopter, as set out in the employers requirement under the COSHH regulations 2002 with regards to diesel engine exhaust emissions.

I am treating your correspondence as a request for information under the Freedom of Information Act 2000 (FOIA). We have now completed a search of our paper and electronic records for the information you requested and I can confirm that some information within the scope of your request is held.

I enclose a copy of the Royal Air Force Institute of Health "*A report on a preliminary survey to assess aircrew exposure to Sea King helicopter exhaust*" (IofH/13/99) which is dated March 1999 rather than March 2015.

Section 40(2) has been applied to the names of individuals in order to protect personal information as governed by the Data Protection Act 1998. Section 40 (Personal Information) is an absolute exemption and there is therefore no requirement to consider the public interest in making a decision to withhold the information.

There are no records pertaining to personal monitoring carried out on Royal Air Force Sea King Search and Rescue helicopters in connection with diesel engine exhaust emissions. Under Section 16 (Advice and assistance) of the Act, you may wish to note that the Sea King helicopter used Avtur and not diesel. You may also wish to note that having reviewed the COSHH regulations 2002 we have been unable to identify a stipulated requirement for personal monitoring in relation to diesel exhaust emissions.

If you are not satisfied with this response or you wish to complain about any aspect of the handling of your request, then you should contact me in the first instance. If informal resolution is not possible and you are still dissatisfied then you may apply for an independent internal review by contacting the Information Rights Compliance team, 2nd Floor, MOD Main Building, Whitehall, SW1A 2HB (e-mail CIO-FOI-IR@mod.uk). Please note that any request for an internal review must be made within 40 working days of the date on which the attempt to reach informal resolution has come to an end.

If you remain dissatisfied following an internal review, you may take your complaint to the Information Commissioner under the provisions of Section 50 of the Freedom of Information Act. Please note that the Information Commissioner will not investigate your case until the MOD internal review process has been completed. Further details of the role and powers of the Information Commissioner can be found on the Commissioner's website, http://www.ico.gov.uk.

Yours sincerely

[redacted]
Secretariat 3a1
Air Command

ROYAL AIR FORCE

INSTITUTE OF HEALTH

OCCUPATIONAL HYGIENE DEPARTMENT

A REPORT ON A PRELIMINARY SURVEY TO ASSESS AIRCREW EXPOSURE TO SEA KING HELICOPTER EXHAUST

Report No: IofH/13/99

March 1999

ROYAL AIR FORCE INSTITUTE OF HEALTH

A REPORT ON A PRELIMINARY SURVEY TO ASSESS AIRCREW EXPOSURE TO SEA KING HELICOPTER EXHAUST

REPORT NO: IofH/13/99

SUMMARY

1. The preliminary survey showed that rear aircrew in Sea King helicopters were being exposed to the particulate component of exhaust "gases". The survey failed to indicate with any accuracy the actual personal exposure level due to the effects of high wind speeds caused by the down-wash from the rotor blades.

2. As the survey failed to demonstrate adequate control, measures should be taken to reduce exposure to as low a level as is reasonably practicable. Recommendations are made.

[redacted]
Flight Lieutenant
Acting Officer Commanding
Occupational Hygiene Department

[redacted]
Wing Commander
Officer Commanding
Royal Air Force
Institute of Health

24 March 1999

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ROYAL AIR FORCE INSTITUTE OF HEALTH

A REPORT ON A PRELIMINARY SURVEY TO ASSESS AIRCREW EXPOSURE TO SEA KING HELICOPTER EXHAUST

References:

A. 22HQ/42/Air dated 23 Apr 98.
B. Unreferenced letter from Duty Winchman, A Flt 202 Sqn dated 14 Apr 98.
C. PTC/451035/9/1/Med dated 16 Jun 98.
D. The Health and Safety at Work Etc Act 1974.
E. The Control of Substances Hazardous to Health (COSHH) Regulations 1994.
F. HSE EH40.
G. Patty's Industrial Hygiene and Toxicology. ISBN 0471-9258-4.
H. Harrington and Gill. Occupational Health, 3rd Edition. Blackwell Scientific Publications.
I. HSE Toxicity Review 2: Formaldehyde. 1982.
J. MDHS 14/2.
K. MDHS 72.
L. NIOSH Method 2541.

INTRODUCTION

1. Reference A covered Reference B in which concerns were expressed that rear aircrew in Sea King helicopters were routinely exposed to jet engine exhaust "fumes" whenever they were positioned in the open cabin doorway whilst the aircraft was hovering or engaged in ground engine running.

2. At Reference C, the Occupation Hygiene Department (OHD) of the RAF Institute of Health was tasked with addressing the questions raised at Reference B, namely:

a. Are the exhaust "gases" harmful?

b. What are the health and safety implications of being exposed to and breathing in these hot "gases" over a prolonged period?

c. What are the possibilities of diverting the starboard engine exhaust gases along the outside of the transmission servicing platform to clear the winching arm and the cabin door?

3. In addition, it was mentioned that, following a 15 minute winching operation, the winch operator's face and helmet were covered in soot. This would indicate that there was a possible problem of exposure to particulates.

4. Owing to the complexity of the task, a preliminary survey was undertaken on 9 Nov 98 to assess the situation and carry out monitoring to determine the presence of some of the possible contaminants.

BACKGROUND

5. **Standards.** Reference D, together with Reference E, require all employers to ensure, so far as is reasonably practicable, that the exposure of employees to substances hazardous to health is prevented, or adequately controlled. Adequate control is deemed to have been achieved if the standards at Reference F are met. The standard that applies to the results from this survey is as follows:

a. **Occupational Exposure Standard.** An Occupational Exposure Standard (OES) is the concentration of an airborne substance, averaged over a reference period, at which, according to current knowledge, there is no evidence that it is likely to be injurious to employees if they are exposed by inhalation, day after day, to that concentration.

6. **Products of Exhaust Gases.** AVTUR (NATO F-34) is a complex mixture of hydrocarbons, typically in the C_9-C_{16} range. Exhaust gases from the combustion of AVTUR may contain many several toxic substances, including gases (such as carbon monoxide (CO), oxides of nitrogen (NOx), sulphur dioxide (SO_2) and carbon dioxide (CO_2)), total hydrocarbons (including benzene) and particulates. In addition, alkenes, aromatics, polycyclic aromatic hydrocarbons (PAH) and aldehydes (in particular, formaldehyde (HCHO)) are cited as atmospheric contaminants emitted in aircraft engine exhausts. However, the majority of these are emitted in extremely low concentrations, ie below the level at which satisfactory continuous measurement techniques have been developed, therefore, with the exception of formaldehyde, these additional contaminants were omitted from the preliminary survey. Furthermore, the difficulties which would have been encountered in using the direct reading instruments at the disposal of the OHD for the detection of the gases (ie CO, CO_2, NOx and SO_2) in the rear of the helicopter also precluded monitoring for these substances in the preliminary survey.

7. **Toxicology of Exhaust Contaminants:**

a. **Sulphur Dioxide.** SO_2 chiefly attacks the upper respiratory tract and the bronchi, and may cause oedema of the lungs or glottis (Reference G). The average person can detect levels of 0.3-1 parts per million (ppm) by taste rather than smell. A level of 3ppm has an easily noticeable odour. A concentration of 6-12ppm causes immediate irritation of the nose and throat.

At higher levels, SO_2 can be hazardous to the eyes; at exposures of 200ppm it causes irritation and inflammation of the conjunctiva.

b. **Carbon Monoxide.** CO is a product of incomplete combustion. It has an affinity for haemoglobin (Hb) 210 times that of oxygen; by combining with Hb, CO renders it incapable of carrying oxygen around the body. However, repeated exposure to concentrations of less than 100ppm of CO in air are not believed to cause any sign of poisoning or permanent damage (Reference G). Furthermore, almost all of any CO inhaled is eliminated through the lungs when a previously exposed person re-enters a CO free atmosphere.

c. **Nitrogen Monoxide.** NO is highly irritating to the respiratory tract, skin, eyes and mucous membranes. Because it has a relatively low solubility in water, NO is only slightly irritating to the upper respiratory tract and potentially dangerous amounts may be breathed in before any discomfort is noticed. Amounts in the range of 60-150ppm cause immediate irritation of the nose and throat. Concentrations in the range 200-700ppm may be fatal even after very short exposures (Reference G).

d. **Nitrogen Dioxide.** NO_2 is produced from the combustion of fossil fuel and, in general, higher combustion temperatures yield more nitrogen oxides. It has been established that NO_2 is more toxic than NO. However, for industrial exposures it matters little whether nitrogen oxides enter the air as NO or NO_2 since any NO gradually changes to NO_2. This mixture is referred to as NOx. Severe exposure to NO_2 can result in pulmonary oedema. Chronic exposure can manifest in transient patchy-lung opacities on chest radiography (Reference H).

e. **Formaldehyde.** HCHO is a severe irritant to the eyes and upper respiratory tract. The threshold for mild irritation may be as low as 0.01ppm (Reference I), however, the intolerable irritant property of HCHO precludes substantial exposure under normal conditions. Reference I concluded that there was no evidence to suggest that exposure to formaldehyde has produced cancer in humans.

f. **Hydrocarbons.** Hydrocarbons are compounds of carbon and hydrogen and are generally classified as aromatic or aliphatic. Most aliphatic hydrocarbons are non-toxic or have a low toxicity, although they can irritate the upper respiratory tract and depress the central nervous system. Aromatic hydrocarbons (mainly types of benzene, toluene and xylene) have a higher toxicity and chronic continuous or repetitive exposure may cause blood disorders. Benzene is a recognised human carcinogen.

g. **Particulates.** The term "particulate" describes an aerosol comprising airborne solid or liquid particules dispersed in a gas stream. In considering the physiological effects, the most important factor is particle size, which

determines where various sized particles may be deposited in the respiratory system. Reference J distinguishes between 2 fractions of particulates:

(1) **Respirable:** ie that which approximates to the fraction of airborne material which penetrates to the gas exchange region of the lung. This fraction has an aerodynamic diameter of less than 3.5μm.

(2) **Total Inhalable:** ie that which approximates to the fraction of airborne material which enters the nose and mouth during breathing and is therefore available for deposition in the respiratory tract. This fraction typically applies to particulates ranging in size up to 100μm.

METHOD

8. The winchman was fitted with a harness containing a variety of sampling devices. Sampling was undertaken during a sortie lasting 48 minutes which included simulated deck and cliff winches (of 14 minutes and 4 minutes duration respectively) and hovering "in ground effect" (IGE) for 3 minutes. Monitoring was carried out for the following contaminants:

a. Total hydrocarbons, in accordance with Reference K, for subsequent quantitative analysis.

b. Formaldehyde, in accordance with Reference L, for subsequent quantitative analysis.

c. Particulates, both total and respirable, in accordance with Reference J for subsequent quantitative analysis. Monitoring for particulates was also undertaken using a Hand-held Aerosol Monitor (HAM).

9. Grab samples were collected from the carbonated areas around the exhaust outlets for subsequent qualitative analysis.

10. Qualitative analysis of the grab samples and quantitative analysis for hydrocarbons and formaldehyde were carried out by the DERA laboratory, Puriton.

RESULTS

11. The results of quantitative analysis for formaldehyde, hydrocarbons and particulates are tabulated at Table 1 at Annex A. They show that:

a. No formaldehyde was found at a concentration greater than the lower limit of detection.

b. Toluene was the only component in the sample supplied for analysis for total hydrocarbons identified as being distinct from the blank sample. The level measured was insignificant when compared to the OES at Reference F.

c. The results of monitoring for total respirable particulates were also insignificant when compared to the OES at Reference F.

12. No measurable quantity of airborne particulates was detected by the HAM.

13. Qualitative analysis of the grab samples was carried out using a Scanning Electron Microscope (SEM) and, in addition, some samples were subjected to Energy Dispersive X-ray (EDX) analysis. The findings are summarised as follows:

a. Figure 1 at Annex B shows the results of EDX analysis of one of the samples and indicates the presence of carbon (C), sodium (Na), sulphur (S), chlorine (Cl) and calcium (Ca). The origin of these elements is not known, however, a mixture of sea spray and fuel exhaust would be the most likely explanation.

b. Figure 2 at Annex B shows a Secondary Electron Image of a typical particulate area. The particles appear to consist of agglomerates of much finer particles, most of which are less than one μm in size.

c. Figure 3 at Annex B shows an SEM image of an uncontaminated area of the edge of a filter used to sample for respirable dust, at x10,000 magnification. Figure 4 at Annex B shows an equivalent "contaminated" area of the filter at the same magnification; a very fine deposit can be seen over most of the surface of the filter. Most of this fine particulate matter is significantly sub-micron in size.

DISCUSSION

14. It is extremely difficult to undertake personal exposure monitoring in high wind speeds. The down-wash from the rotor blades has a substantial influence on the dynamics of contaminants in air, thus negating or reducing the concentration being presented to the relevant capture media. The best advice offered by the Health and Safety Executive (HSE) laboratory was to use conventional methods, which would probably indicate levels lower than those that actually existed (ie the levels obtained would be likely to be an under-estimation of the actual personal exposure level). Given the monitoring techniques currently available, this situation is unlikely to change in the short term.

15. As already stated, Reference D, together with Reference E, require all employers to ensure, so far as is reasonably practicable, that the exposure of employees to substances hazardous to health is prevented, or adequately controlled. The failure of this survey to demonstrate, with any confidence, that toxic substances

are being adequately controlled means that everything that is reasonably practicable should be carried out to ensure that exposure of personnel to contaminants is reduced to as low a level as possible.

16. It is not within the remit of this department to comment on re-engineering methods with regard to the aircraft. However, the diversion of the starboard engine exhaust along the outside of the transmission servicing platform to clear the winching arm and cabin door would reduce the possibility of exposure of operatives to toxic contaminants in the exhaust gases.

CONCLUSIONS

17. The questions raised at Reference B and outlined in paras 2a-b have been addressed in this report.

18. The results of quantitative analysis of samples collected during this survey were inconclusive.

19. The results of qualitative analysis of the grab samples indicated the presence of sub-micron particulates in the exhaust gases which may be inhaled and deposited in the alveolar/gas exchange region of the lungs.

20. Any attempt to quantify the actual exposure of winchmen to contaminants from engine exhaust whilst engaged on operations in the rear of a Sea King helicopter would be hampered by the high wind speeds generated by the down-wash from the rotor blades and would thus be nugatory.

RECOMMENDATIONS

21. The following recommendations are made:

a. The engineering authority should consider the possibility of diverting the starboard engine exhaust gases along the outside of the transmission servicing platform to clear the winching arm and the cabin door.

b. If any further monitoring is to be carried out in connection with this task, attempts should be made to monitor for CO, CO_2, NO, NO_2 and SO_2.

ANNEX A TO
IofH/13/99
DATED 24 MAR 99

TABLE 1

Results of Quantitative Analysis of Samples

Sample No	Substance	Flow Rate (ml/min)	Sample Time (mins)	Quantity (mg/m^3)
HAL/98/139/1	Formaldehyde	100	48	< 0.2
HAL/98/139/2	Formaldehyde	Blank	Blank	< 0.2
HAL/98/141/1	Total Hydrocarbons	50	38	0.17
1	Particulates - Total	2000	48	0.6
2	Particulates - Respirable	2200	48	0.2

ANNEX B TO
IofH/13/99
DATED 24 MAR 99

FIGURE 1

Results of Analysis of a Sample Using Energy Dispersive X-ray

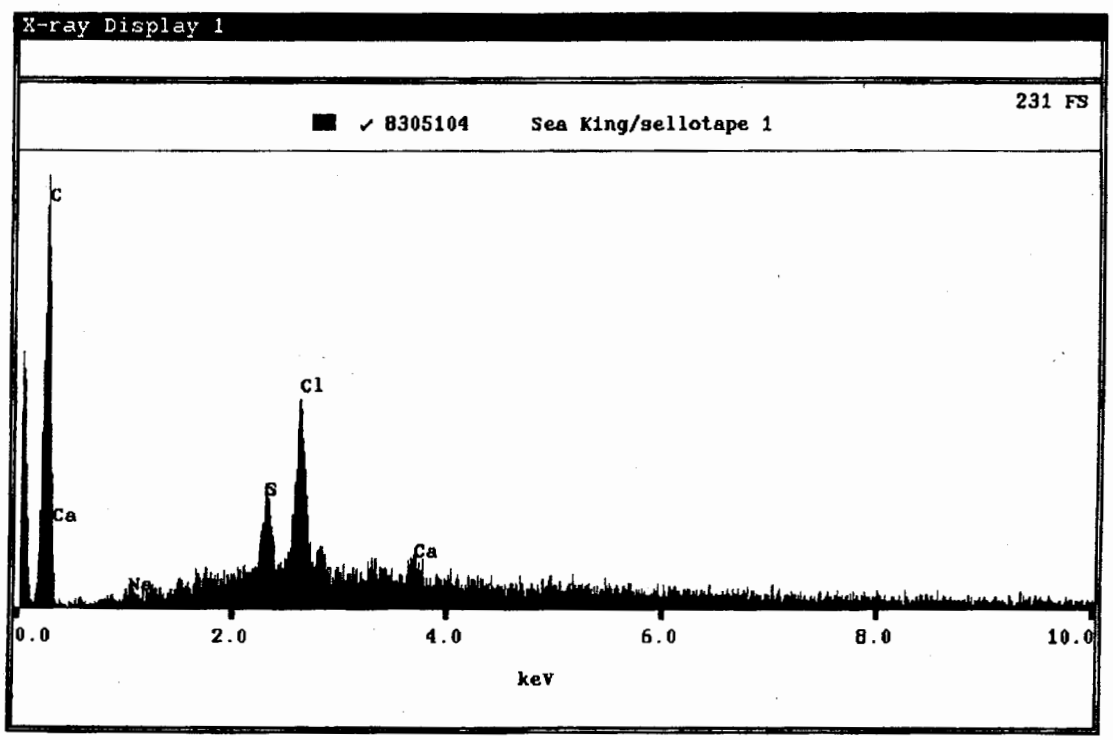

FIGURE 2

Secondary Electron Image of a Typical Particulate Area

FIGURE 3

SEM Image of Uncontaminated Edge of Filter (x10,000 Magnification)

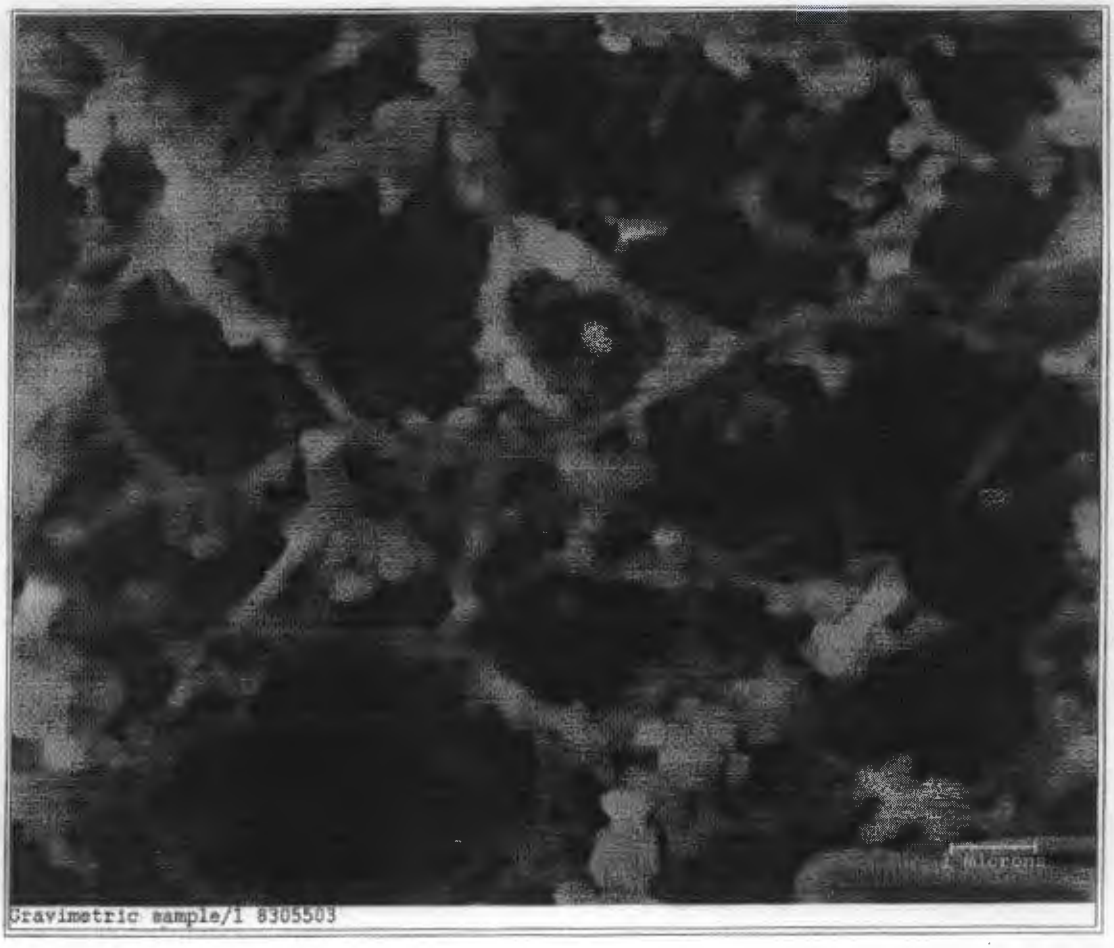

FIGURE 4

SEM Image of Contaminated Area of Filter Showing Deposit of Fine Particulate Matter