NRL Memorandum Report 2182

Measurement and Removal of Freon-TF From a Submarine Atmosphere

Report of Trip to USS SALMON, SS-573

HAROLD G. EATON

Chemical Dynamics Branch
Chemistry Division

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NAVAL RESEARCH LABORATORY
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ABSTRACT

Due to possible contamination of the atmosphere of the submarine USS SALMON, SS-573, with Freon-TF during a cleaning operation of a motor generator at San Diego, a request was made by the Naval Ship Engineering Center for an NRL representative to provide on-the-spot analytical assistance and technical guidance. A commercially built Total Hydrocarbon Analyzer was used to monitor the atmosphere during and after the cleaning. The highest level of Freon-TF, 2.5%, was recorded in the bilge area during the cleaning operation, indicating that liquid Freon had collected in this area. Using two blowers, approximately 80 hours of ventilation time was needed to get down to a Freon-TF concentration of 10 ppm in the affected compartments.

PROBLEM STATUS

This is a final report on this phase of the problem; work on other phases of the problem is continuing.

AUTHORIZATION

NRL Problem C08-18
Project S 4632-002-12073

MEASUREMENT AND REMOVAL OF FREON-TF FROM A SUBMARINE ATMOSPHERE (Report of Trip to USS SALMON, SS-573)

Harold G. Eaton

INTRODUCTION

For several years, the Naval Research Laboratory has maintained a program in the purification, detection, and control of unwanted contaminants in closed atmospheres. In this regard, various techniques have been developed to detect and monitor volatile contaminants in closed systems such as submarines. The Bureau of Medicine and Surgery has classified as undesirable many volatile contaminants, particularly ones containing halogen atoms such as chlorine.

A continuing problem in atmosphere control is the increasing use of various cleaning solvents in submarine upkeep and overhaul. A new technique developed by the Naval Ship Engineering Center, Philadelphia Division, to clean motor generators in-place on fleet submarines employs the use of 1,1,2-trichloro-1,2,2,-trifluoroethane (1). This solvent may be purchased under such trade names as Freon-113, Freon-TF, and Freon-PCA.

It has been reported that personnel who are overexposed to this particular solvent may incur central nervous system depression and injury to the liver and kidneys from single or repeated exposures (2). Further, it has been found that this solvent can cause unnatural human heart action due to stimulation of the adrenalin system (3).

Recently, the engineering staff of the submarine tender, USS NEREUS, AS-17, stationed at San Diego, California, scheduled a cleaning operation for the No. 4 motor generator aboard the USS SALMON, SS-573. Because of past experience by NRL chemists with a similar cleaning operation aboard the USS STONEWALL JACKSON, SSBN634, (4), NRL was requested by NAVSEC, Code 6151C, to provide analytical assistance and technical guidance in this instance.

In response to this request, a chemist was assigned by NRL to provide analytical and consultative services for this event. A commercially built Total Hydrocarbon Analyzer (THA) was shipped from NRL to the site for use in monitoring the solvent and determining its concentration in the ship's atmosphere.

ATMOSPHERE MONITORING WITH THE TOTAL HYDROCARBON ANALYZER

The NRL chemist, accompanied by two representatives from NAVSEC, Philadelphia Division, arrived in San Diego on 21 July 1970. On 22 July, the THA was installed on the top deck of the USS SAIMON and was made operational preparatory to monitoring the atmosphere below decks beginning 23 July.

23 July. Two Red Devil blowers were positioned to exhaust the vapor of the cleaning solvent, Freon-TF. Hatches forward and aft of the Engine Room were secured to prevent contamination of the rest of the boat, leaving only the top hatch open for entrance into the area. Inspection of the bilge area indicated the absence of water or other liquid. One of the exhaust hoses from the Red Devil was positioned in this area, the other, in the generator compartment.

A background analysis of the affected compartments revealed no contaminant present that would interfere with the analysis of Freon-TF by the THA. Background readings were also taken of the exhaust from the Red Devil blowers with the same result.

At 1100 hours the cleaning of the No. 4 generator commenced and was conducted in accordance with reference (5). Approximately 83 gallons of liquid Freon-TF was used for each of the wash cycles.

As noted in Table 1, the first detectable level of Freon-TF in the Engine Room was recorded at 1155. At 1210 hours, this concentration rose from 760 to 2840 ppm. At 1250 hours, a sample taken from the Red Devil exhaust coming from the bilge area indicated 2560 ppm, showing a leakage in this area. At 1340 hours, samples taken directly from the bilge and from the Red Devil blower indicated 2.5% (25,000 ppm) of Freon-TF. The generator compartment had a high recording of 2100 ppm at 1600 hours. The second wash was completed at approximately 1400 hours.

Physical inspection of the bilge area revealed the presence of liquid solvent. This area was hand-wiped dry.

The Red Devil blowers were left to ventilate the compartments overnight.

24 July. An analysis of the affected area with the Red Devils still in operation indicated a high of 12 ppm in the generator area at 1456 hours. In order to obtain a true picture of the equilibrium level of Freon-TF still present in the compartment, it was necessary to secure the compartment without ventilation for at least 8 hours. Hence, the Red Devils were turned off at 1900 hours and the area was secured until 0900 on 25 July.

25 July. After having been secured for approximately 14 hours prior to analysis, the Generator and Engine compartments registered 170 and 150 ppm, respectively. The Red Devils were turned on again at 1000 hours and off at 0600 hours on 26 July.

26 July. Prior to analysis, the compartments were secured for approximately 7 hours. An analysis of the Generator and Bilge compartments indicated concentrations of Freon-TF of 29 and 27 ppm, respectively. The blowers were energized again at 1400 hours and secured at 0400 hours on 27 July.

27 July. The compartments were secured again for approximately 8 hours. Analyses of the air indicated a level for the Engine Room and Bilge area to be 18 ppm and that in the Generator level to be 22 ppm.

28 July. After further ventilation on the 27th, the compartments were secured for 8 hours prior to analysis. Samples taken from the three compartments indicated a high of 10 ppm found in the Generator area.

ADDITIONAL INFORMATION

A typical chart record of the analysis of the submarine atmosphere is shown in Figure 1. The THA was operated in a normal gas chromatographic fashion until after the detection and elution of the Freon-TF. The carrier gas passing through the separation column was then reversed to regroup the remaining contaminants into one measurable total hydrocarbon peak. As indicated in Table 1, the background concentration of total hydrocarbons was approximately 30 mg/m^3. This value increased to a recorded 70 mg/m^3 in the Bilge area during the washing operation on 23 July.

In general, as the concentration of the Freon-TF decreased, the total hydrocarbon concentration also decreased. An exception to this, however, was noted on 26 July at 1345 hours from a sample taken in the Bilge area where a recording of 62 mg/m^3 of hydrocarbon was recorded in contrast to samples taken in the other two areas, Engine and Generator levels, where the recordings were 29 and 37 mg/m^3, respectively.

As discussed previously, in order to obtain a true picture of the equilibrium level of the Freon-TF present in the compartment, the compartment must be secured for approximately 8 hours prior to analysis. These data, condensed from Table 1, are presented in Table 2. As shown in Table 2, a 10 ppm v/v concentration of Freon-TF was recorded after some 79 hours of total ventilation time.

REFERENCES

1. "In-Place Cleaning of Propulsion Generators Using Freon-TF, Proposed Instructions for," NAVSEC PHIL ltr 6732/ADA:36, 9410 (T-495) of 12 February 1968

2. "In-Place Cleaning of Propulsion Generators Using Trichlorotrifluoroethane," BUMED ltr 732-SHB:snp of 2 January 1970

3. Private communication with Dr. C. F. Reinhardt of the Environmental Sciences Group, Dupont-Haskell Lab., Newark, Delaware, of 1 July 1970

4. Williams, F. W., "Contamination of Submarine Atmosphere with Freon-TF (Report of Trip to SUBRON 15)," NRL Memorandum Report 1907 of August 1968

5. "In-Place Cleaning of Electrical Rotating Equipment with Cleaning Compound, Solvent, Trichlorotrifluoroethane, MIL-C-81302," NAVSHIPS Notice 9610, 6157C:CBZ/WPS:ec Ser 196 of 10 March 1970.

Table 1

ANALYSIS OF ATMOSPHERE SAMPLE FROM USS SALMON, SS-573

Date	Time, Hours	Sample Location	Freon-TF ppm	THc mg/m^3	Remarks
7/23/70	0850	Red Devil exhaust from Generator compartment	--	30	Background level
7/23/70	0900	Red Devil exhaust from Bilge area	--	25	Background level
7/23/70	1155	Generator level	760	N/A	Cleaning operation began at 1100
7/23/70	1210	Engine Room level	2840	N/A	
7/23/70	1225	Red Devil-Generator	304	N/A	
7/23/70	1235	Generator level	236	N/A	First wash completed
7/23/70	1250	Red Devil-Bilge	2560	70	
7/23/70	1325	Generator level	960	N/A	Second wash completed
7/23/70	1340	Bilge area	25000	N/A	
7/23/70	1408	Red Devil-Bilge area	26500	N/A	
7/23/70	1427	Generator level	1200	N/A	
7/23/70	1445	Engine level	636	N/A	

Table 1 (Cont'd.)

Date	Time, Hours	Sample Location	Freon-TF ppm	THc mg/m^3	Remarks
7/23/70	1530	Engine level	419	N/A	Engines were run for approx. 10 minutes
7/23/70	1600	Generator level	2100	27	After 12 minutes engine run
7/23/70	1615	Generator level	91	20	Red Devil blowers left on overnight
7/24/70	0934	Engine level	0.9	N/A	
7/24/70	0945	Generator level	0.9	N/A	
7/24/70	1406	Red Devil-Generator	3	27	
7/24/70	1417	Red Devil-Bilge area	2	27	
7/24/70	1440	Bilge area	2	27	
7/24/70	1456	Generator level	12	27	
7/24/70	1900	--	--	--	Red Devils turned off and Engine area secured
7/25/70	0935	Generator level	170	62	Engine area secured for approx. 14 hrs., total hrs. of ventilation was 30

Table 1 (Cont'd.)

Date	Time, Hours	Sample Location	Freon-TF ppm	THc mg/m^3	Remarks
7/25/70	1013	Enginc level	150	62	
7/25/70	1020	--	--	--	Red Devils turned on with one blowing in on the top of Generator and the other pulling air out of the Bilge area
7/25/70	1750	Engine level	17	N/A	
7/26/70	0600	--	--	--	Engine area secured
7/26/70	1325	Engine level	27	29	Area was secured for approx. 7 hrs., total ventilation was 50 hrs.
7/26/70	1335	Generator level	29	37	
7/26/70	1345	Bilge area	27	62	
7/26/70	1400	--	--	--	Red Devils turned on
7/27/70	0400	--	--	--	Engine area secured, total ventilation was 64 hrs.
7/27/70	1200	Engine level	18	21	Engine area was secured for 8 hrs.

Table 1 (Cont'd.)

Date	Time, Hours	Sample Location	Freon-TF ppm	THc mg/m^3	Remarks
7/27/70	1215	Bilge area	18	21	
7/27/70	1225	Generator area	22	21	
7/27/70	1230	--	--	--	Red Devils turned on
7/28/70	0300	--	--	--	Engine area secured, total ventilation was 79 hours
7/28/70	1100	Engine level	5	34	Area was secured for 8 hours
7/28/70	1110	Bilge area	6	34	
7/28/70	1130	Generator area	10	34	

Note: N/A = not analyzed

Table 2

EQUILIBRIUM CONCENTRATION OF FREON-TF AFTER VENTILATION

Total hours ventilated after in-place cleaning	No. of hours area was secured prior to analysis	Location of Sample	Concentration of Freon-TF (ppm)
39	14	Engine level	150
		Generator compartment	170
50	7	Engine level	27
		Generator compartment	29
		Bilge area	27
64	8	Engine level	18
		Generator compartment	27
		Bilge area	18
79	8	Engine level	5
		Generator compartment	6
		Bilge area	10

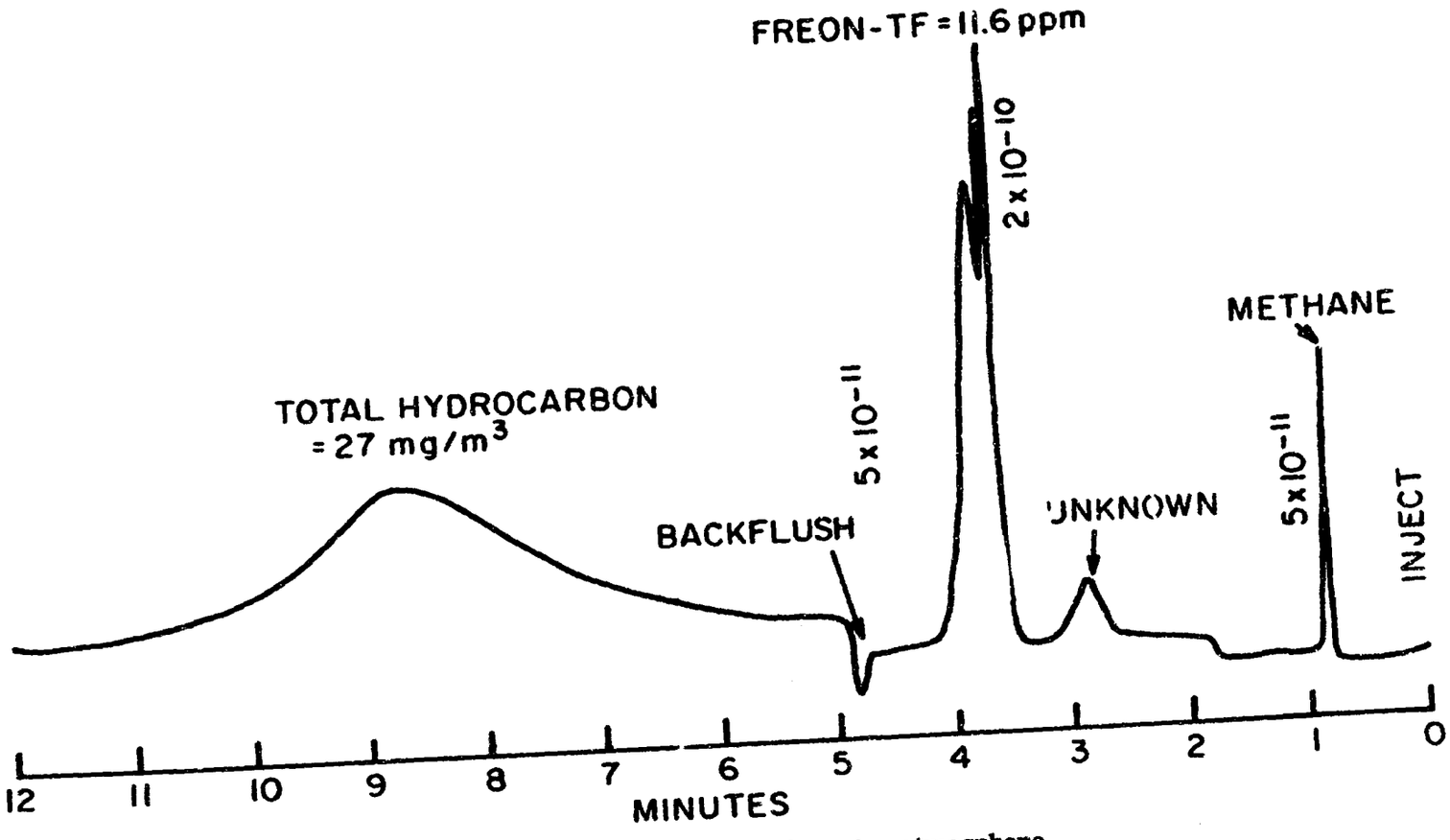

Fig. 1 – Typical analysis of submarine atmosphere

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Harold G. Eaton

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Due to possible contamination of the atmosphere of the submarine USS SALMON, SS-573, with Freon-TF during a cleaning operation of a motor generator at San Diego, a request was made by the Naval Ship Engineering Center for an NRL representative to provide on-the-spot analytical assistance and technical guidance. A commercially built Total Hydrocarbon Analyzer was used to monitor the atmosphere during and after the cleaning. The highest level of Freon-TF, 2.5%, was recorded in the bilge area during operation, indicating that liquid Freon had collected in this area. Using two blowers, approximately 80 hours of ventilation time was needed to get down to a Freon-TF concentration of 10 ppm in the affected compartments.

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Ventilation time						