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A Procedure for Recharging Self-Contained Breathing Apparatus Air Bottles in the Presence of Simulated Chemical Warfare Agents

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The voluntary, fully informed consent of the subjects used in this research was obtained as required by AFR 169-3.

This paper has been reviewed and is approved for publication.

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A procedure was developed and tested for recharging Self-Contained Breathing Apparatus (SCBA) cylinders in an atmosphere contaminated with chemical agent simulant at concentrations which would produce casualties if actual agent were used. With the exception of a rack for storing the cylinders before and after recharging, all items used are currently available commercially or through off-the-shelf DOD supply sources. Cylinders were successfully recharged without contamination in the presence of chemical agent simulant in the compressor area as well as in the cylinder filling area. Inexperienced personnel easily learned and successfully followed the recharging procedures even though they were burdened by protective clothing and equipment.

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CHEMICAL DEFENSE COLLECTIVE PROTECTION TECHNOLOGY: VOLUME 12
A Procedure for Recharging Self-Contained Breathing Apparatus Air Bottles in the Presence of Simulated Chemical Warfare Agents

INTRODUCTION

To reuse a Self-Contained Breathing Apparatus (SCBA), the SCBA tanks must be refilled with clean air. This need is complicated in an environment contaminated by chemical agents, or other toxic materials, in the ambient air used to fill the SCBA air tanks. The situation is further complicated by the need for relatively high pressure (2216 psig). The procedure for refilling the air bottles in a contaminated environment must take into account the possibility that both supply air and compressed air may be contaminated; special precautions must be taken. These precautions and the procedures for recharging SCBA tanks are the subject of this report.

SPECIFIC OBJECTIVE

The specific objective of experiments described in this report was to demonstrate the practicability of recharging SCBA bottles with breathable air in an environment simulating the conditions of an actual chemical agent attack. Simulant was introduced into the air source as well as at the bottle filling area. The three conditions were evaluated by measuring the concentrations of chemical agent simulant in air released from the recharged bottles under each condition. The three conditions were:

(1) Outside air supplied through a filter/blower unit with no simulant present.

(2) Outside air supplied through a filter/blower unit with simulant introduced into the bottle filling area.

(3) Outside air supplied through a filter/blower unit with simulant introduced into both the bottle filling area and the compressor air source area.

EQUIPMENT AND PROCEDURES

Equipment

The final pressure in a standard 30-m^3 SCBA is 2216 psig; therefore, to achieve reasonable filling times, a compressor with a service pressure of 3000-3500 psig was desirable. An MC1A air compressor (Fig. 1), NSN 4310-01-060-0642 (Davey Compressor Co., Cincinnati, Ohio) was attached to an Aero-Dri Model AD-800 air purification system (Fig. 2), NSN 6505-00-104-9000 (Aero-Dri

Corporation, Delray Beach, Florida) and to an oil-sealed compressor that delivered breathing-grade air. The air cylinder service unit was tested for use with a Mobile Collective Protection Shelter for Firefighters (MCPS-F). Excess air furnished to the shelter from a KMU-450 filter/blower system (Fig. 3) was ducted to the compressor for inlet air by replacing the oil bath air inlet filter of the compressor with a 1-in. hose running from the air inlet distribution box of the MCPS-F to the compressor (Fig. 4). To prevent residual contamination in the interior of the filling compartment of the cylinder servicing unit, air from a 200 SCFM Model XM-20 filter/blower unit (Fig. 5) was blown into the bottom of the cylinder filling compartment which was sealed off from the outside with a 6-mil polyethylene sheet, thus furnishing a continuous flush of filtered air to the filling area. SCBA tanks to be serviced were stored in a twelve-place custom-fabricated storage unit (Fig. 6). Cylinders were refilled using an Eagle Air Systems Model 60-300A cylinder servicing unit (Eagle Air Systems Division of Pressure Systems, Inc., P.O. Box 458, Pleasant Garden, NC 27313). The control panel is shown in Figure 7, and the bottle charged side in Figure 8. All equipment except the compressor was mounted in a trailer, and placed in an airtight room for testing in a simulated chemical agent environment (Fig. 9). The exposure area was the Tee section of the SCPS-2B; the openings were closed with polyethylene film.

Procedures

Methyl salicylate (MeS) (7.0-9.0 mg/m^3) was introduced in the air surrounding the cylinder recharging trailer using an MeS generator. Methyl salicylate vapor exposure atmospheres are generated by passing a stream of air over thin films of liquid MeS. The airstream containing MeS vapor is then directed through the exposure booth onto the participants. Actual atmospheric concentrations produced within the booth over the entire exposure period are monitored.

The apparatus employed for vapor generation is located immediately above the exposure booth. An airstream (500 LPM) is produced by a Rotron blower (Model SL 294 FG); its velocity is measured by a Fisher Porter flowmeter (Model 8204800876A). The airstream enters a cylinder into which one or more tubes of Vycor brand porous ("Thirsty") glass (40-Angstrom pore diameter) extend through modified Cajon Ultra-torr S-4UT1-4 fittings. This procedure was followed each time the cylinders were recharged. Each cylinder was analyzed separately, and the values for each cylinder were combined for each replicate.

Air in each cylinder was analyzed by sampling a discharge line flowing at 5.0 LPM with three portable sequential impingers, each sampling at a rate of 1.0 LPM for 15 minutes for each of seven tubes. The air sample was drawn through a glass impinger tube containing a 15-ml hydrolysis solution: 0.2 N (NaOH) in 50% ethanol. Samples of MeS trapped in 1:1 NaOH-methanol are allowed to stand for 24 h prior to assay in order to ensure complete hydrolysis of the MeS. Suitable dilutions of these solutions are prepared by diluting known quantities of neat MeS and assaying the hydrolysis product fluorometrically; these standards are assayed concomitantly before and after each batch of samples using a Perkin-Elmer Model LS-5 or Model 3000 spectrofluorometer. With this assay it is possible to detect 1.45 ng hydrolyzed MeS per milliliter of solution, with a fluorescence yield of 0.6 units at a sensitivity setting of 2. (See Appendix for filling procedure.)

RESULTS

Table 1 lists the MeS vapor concentrations (for the three experimental conditions) in samples from each of eight tests. Samples 1 through 21 were from the first cylinder, samples 22 through 42 were from the second cylinder, and samples 43 through 63 were from the third cylinder charged under each experimental condition.

Table 2 lists the vapor concentrations of MeS in the room where the cylinders were filled, and the concentrations in the compressor area during the same time (MeS #4, MeS #5, and MeS #6). Methyl salicylate concentrations in the inlet area of the recharge air compressor during the contaminated air test are also shown (MeS #4A, MeS #5A, and MeS #6A).

Table 3 contains values for the descriptive statistics used to analyze the air samples from the recharged air cylinders. These values are based upon the raw data as collected, and do not include corrections for missing data points.

Table 4 lists values obtained by a one-factor analysis of variance (ANOVA). The data was tested for significance at the 95% level using the Fisher LSD and Scheffe F-tests.

DISCUSSION AND CONCLUSIONS

Statistical data in Tables 3 and 4 show no contamination in the air used to recharge air cylinders in a simulated chemical agent atmosphere when using the equipment and procedures described in this report. In fact, values were significantly lower in the air from a contaminated atmosphere than in air from the blank (Table 3) which was prepared in the absence of any chemical agent simulant in the immediate area of the cylinders being refilled. This difference could be due to the presence of residual contamination on some of the cylinders used in this test, or possibly the presence of extraneous contamination on the glassware. Whatever the cause, the appearance of values less than the detection limit of the test for

MeS further indicates that there is no significant contamination of the breathing air in the recharged cylinders.

The effect of training and experience on the amount of simulant carried over into the recharged cylinders is illustrated in Tables 2 and 3. The first four tests were done by one individual, and the values fell to a constant value (indicating mastery of the filling procedure and the washout of any carried over contamination). When an untrained individual filled the bottles for the first time, some contamination apparently occurred in the first run (MeS #5). Contaminant values then returned to the previous level (MeS #6), indicating sufficient familiarity with the proper filling procedure.

These data strongly support the conclusion that SCBA air bottles can be refilled in a contaminated (but not an oxygen deficient) environment without significant contamination if proper equipment and procedures are carefully used.

BIBLIOGRAPHY

1. Conkle, J.P., R.E. Miranda, C.J. Oakley. Chemical Defense Collective Protection Technology: Vol 10, Evaluation of a Redesigned Survivable Collective Protection Shelter with Increased Protected Spaces. USAFSAM-TP-90-27, December 1990.

2. Conkle, J.P., R.E. Miranda., J.R. Fischer, Jr., R.W. Page, Jr., D.L. Bartlett. Chemical Defense Collective Protection Technology: Vol 6, Vapor Transport by Two Types of Activated Charcoal Undergarment. USAFSAM-TP-88-6, December 1988.

3. Conkle, J.P., R.E. Miranda, J.R. Fischer, Jr., R.W. Page, Jr., D.L. Bartlett. Chemical Defense Collective Protection Technology: Vol 8, Vapor Transport by Components of U.S. Army Battle Dress. USAFSAM-TP-89-1, November 1989.

TABLE 1. METHYL SALICYLATE VAPOR CONCENTRATIONS (mg/m^3) IN AIR FROM RECHARGED CYLINDERS

SAMPLE	BLANK 1	BLANK 2	MeS 1	MeS 2	MeS 3	MeS 4	MeS 5	MeS 6
1	0.006	0.004	<0.001	0.002	0.001	0.001	0.001	0.001
2	0.004	.004	0.003	0.004	0.003	0.001	0.002	0.001
3	0.004	0.003	0.002	0.005	0.001	0.002	0.001	0.001
4	0.006	0.004	0.002	0.003	0.001	0.001	0.002	0.001
5	0.004	0.003	0.003	0.002	0.001	0.001	0.002	0.001
6	0.005	0.005	0.003	0.003	0.002	0.002	0.002	0.001
7	0.005	0.007	0.004	0.003	0.004	0.001	0.001	0.001
8	0.004	0.003	0.006	0.003	0.001	0.001	0.004	<0.001
9	0.003	0.003	0.004	0.003	0.003	0.002	0.002	<0.001
10	0.005	0.003	0.004	0.004	0.002	<0.001	0.002	<0.001
11	0.005	0.004	0.004	0.003	0.002	0.001	0.004	<0.001
12	0.004	0.003	0.004	0.002	0.002	<0.001	0.003	<0.001
13	0.006	0.004	0.004	0.002	0.002	0.001	0.002	<0.001
14	0.006	0.005	0.006	0.004	0.008	0.005	0.003	<0.001
15	0.008	0.006	0.003	0.006	0.001	0.001	0.004	<0.001
16	0.005	0.004	0.002	0.007	0.001	0.002	0.004	<0.001
17	0.005	0.004	0.006	0.005	0.001	0.001	0.004	<0.001
18	0.004	0.005	0.004	0.013	0.001	0.002	0.004	<0.001
19	0.007	0.003	0.003	0.006	0.002	0.002	0.002	<0.001
20	0.005	0.003	0.003	0.004	0.001	0.002	0.002	<0.001
21	0.005	0.004	0.004	0.007	0.003	0.002	0.002	<0.001
22	0.004	0.003	0.005	0.002	0.001	0.001	0.002	0.001
23	0.003	0.002	0.004	0.002	<0.001	0.001	0.002	0.001
24	0.003	0.004	0.005	0.001	0.001	0.002	0.002	0.001
25	0.005	0.003	0.005	0.002	<0.001	0.005	0.003	0.001
26	0.004	0.002	0.006	0.003	0.001	0.002	0.002	0.001
27	0.002	0.003	0.005	0.002	<0.001	0.001	0.001	0.001
28	0.008	0.003	0.004	0.004	0.002	0.001	0.003	0.001
29	0.003	0.004	0.004	0.003	0.001	0.002	0.002	<0.001
30	0.004	0.004	0.004	0.002	<0.001	0.005	0.003	0.001
31	0.005	0.004	0.005	0.007	0.001	0.001	0.003	<0.001
32	0.005	0.002	0.001	0.003	0.001	0.002	0.003	<0.001
33	0.004	0.003	0.004	0.010	0.001	0.002	0.002	<0.001
34	0.004	0.004	0.005	0.004	0.001	0.001	0.002	<0.001
35	0.005	0.005	0.006	0.003	0.001	0.001	0.002	<0.001
36	0.005	-.---	0.006	0.003	0.002	<0.001	0.002	<0.001
37	0.005	-.---	0.004	0.002	0.001	0.001	0.002	<0.001
38	0.005	-.---	0.005	0.002	0.001	0.004	0.002	<0.001
39	0.007	-.---	0.005	0.003	0.003	0.002	0.002	<0.001
40	0.005	-.---	0.007	0.004	0.001	<0.001	0.002	<0.001
41	0.007	-.---	0.004	0.004	0.002	0.001	0.002	<0.001
42	0.006	-.---	0.004	0.003	0.001	0.003	0.002	<0.001
43	0.005	0.003	0.004	0.003	0.001	0.001	0.002	0.001
44	0.003	0.003	0.004	0.004	0.001	0.002	0.002	0.001
45	0.004	0.003	0.005	0.006	0.001	0.001	0.003	0.001
46	0.005	0.007	0.004	0.003	0.002	0.001	0.002	0.001

TABLE 1. Cont'd

SAMPLE	BLANK 1	BLANK 2	MeS 1	MeS 2	MeS 3	MeS 4	MeS 5	MeS 6
47	0.003	0.003	0.004	0.002	0.001	<0.001	0.003	0.001
48	0.005	0.003	0.004	0.003	0.001	0.002	0.001	0.001
49	0.004	0.003	0.004	0.002	0.001	0.002	0.001	0.002
50	0.004	0.008	0.004	-.---	0.001	0.002	0.001	<0.001
51	0.003	0.012	0.005	-.---	0.001	0.002	0.001	<0.001
52	0.004	0.007	0.005	-.---	0.001	0.001	0.001	<0.001
53	0.004	0.005	0.005	-.---	0.004	0.002	0.003	<0.001
54	0.004	0.004	0.006	-.---	0.002	0.002	0.003	<0.001
55	0.005	0.004	0.005	-.---	0.001	0.001	0.002	<0.001
56	0.005	0.004	0.005	-.---	0.002	0.002	0.003	<0.001
57	0.005	0.010	0.006	0.003	0.002	<0.001	0.004	<0.001
58	0.008	0.010	0.005	0.002	0.001	<0.001	0.001	<0.001
59	0.002	0.007	0.006	0.006	0.002	0.002	0.004	<0.001
60	0.008	0.009	0.005	0.003	0.001	0.001	0.007	<0.001
61	0.004	0.011	0.055	0.002	0.002	0.001	0.002	<0.001
62	0.002	0.008	0.005	0.002	0.001	0.001	0.006	<0.001
63	0.004	0.008	0.006	0.003	0.002	<0.001	0.012	<0.001

TABLE 2. METHYL SALICYLATE VAPOR CONCENTRATIONS (mg/m^3) IN AIR SURROUNDING SCBA CYLINDERS DURING RECHARGE

TEST	N	MEAN	S.D.	STANDARD ERROR MEAN	MAXIMUM	MINIMUM
BLANK	23	0.012	0.010	0.002	0.037	0.005
MeS #1	14	9.026	3.555	0.950	15.344	1.619
MeS #2	16	7.335	2.392	0.598	11.277	3.558
MeS #3	16	8.713	3.275	0.819	13.927	3.030
MeS #4	16	8.078	3.735	0.934	14.133	1.024
MeS #5	16	8.774	2.069	0.517	11.260	2.974
MeS #6	13	7.025	2.384	0.661	11.840	3.610
MeS #4A	16	2.575	1.860	0.465	6.480	0.760
MeS #5A	16	2.304	1.548	0.387	5.588	0.116
MeS #6A	13	0.520	0.539	0.150	1.673	0.011

TABLE 3. MEAN METHYL SALICYLATE VAPOR CONCENTRATIONS (mg/m^3) IN AIR FROM RECHARGED CYLINDERS

TEST	N	MEAN	S.D.	STANDARD ERROR MEAN	MAXIMUM	MINIMUM
BLANK #1	63	0.005	0.001	0.0001956	0.008	0.002
BLANK #2	56	0.005	0.002	0.0003163	0.012	0.002
MeS #1	63	0.004	0.001	0.0001670	0.007	<0.001
MeS #2	56	0.004	0.002	0.0002862	0.013	0.001
MeS #3	63	0.002	0.001	0.0001499	0.008	<0.001
MeS #4	63	0.001	0.001	0.0001374	0.005	<0.001
MeS #5	63	0.003	0.002	0.0002079	0.012	0.001
MeS #6	63	0.00042	0.00047	0.0000588	0.0001	0.002

TABLE 4. RESULTS OF ONE-FACTOR ANOVA

COMPARISON	MEAN DIFFERENCE	FISHER	SCHEFFE	DUNNETT-t
BLANK #1 VS BLANK #2	0.0002	0.001	0.048	0.582
BLANK #1 VS MeS #1	0.0004	0.001	0.239	1.293
BLANK #1 VS MeS #2	0.0010	0.001*	1.493	3.233
BLANK #1 VS MeS #3	0.0030	0.001*	14.349*	10.222
BLANK #1 VS MeS #4	0.0030	0.001*	14.535*	0.087
BLANK #1 VS MeS #5	0.0020	0.001*	4.838	5.819
BLANK #1 VS MeS #6	0.0040	0.001*	24.419	13.074
BLANK #2 VS MeS #1	0.0002	0.001	0.072	0.711
BLANK #2 VS MeS #2	0.0010	0.001*	1.004	2.651
BLANK #2 VS MeS #3	0.0030	0.001*	1.004	2.651
BLANK #2 VS MeS #4	0.0030	0.001*	12.906	9.505
BLANK #2 VS MeS #5	0.0020	0.001*	3.919	5.237
BLANK #2 VS MeS #6	0.0040	0.001*	22.294	12.492

* Significant at 95%

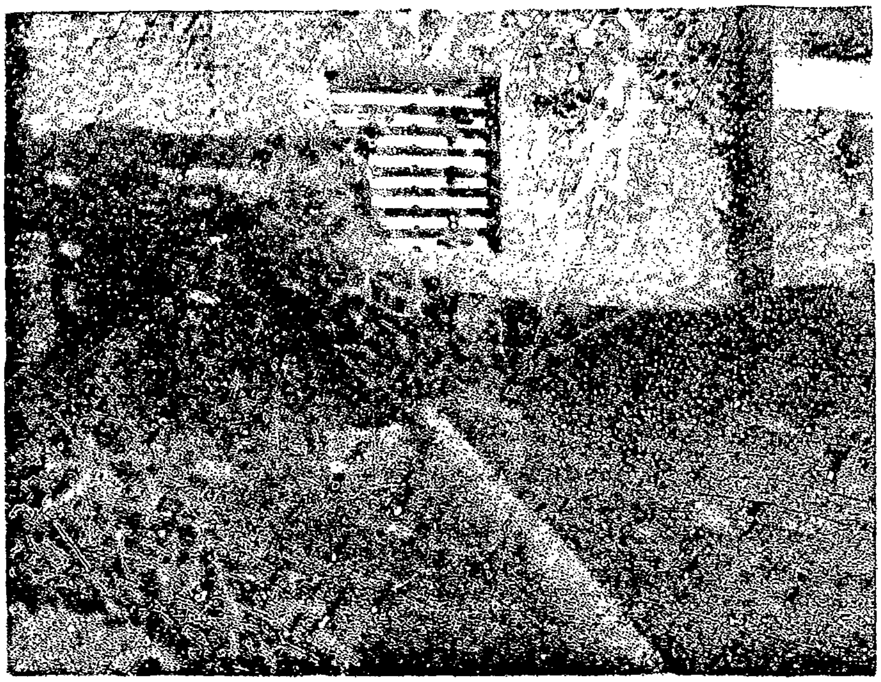

Figure 1. Air compressor.

Figure 2. Air purification system.

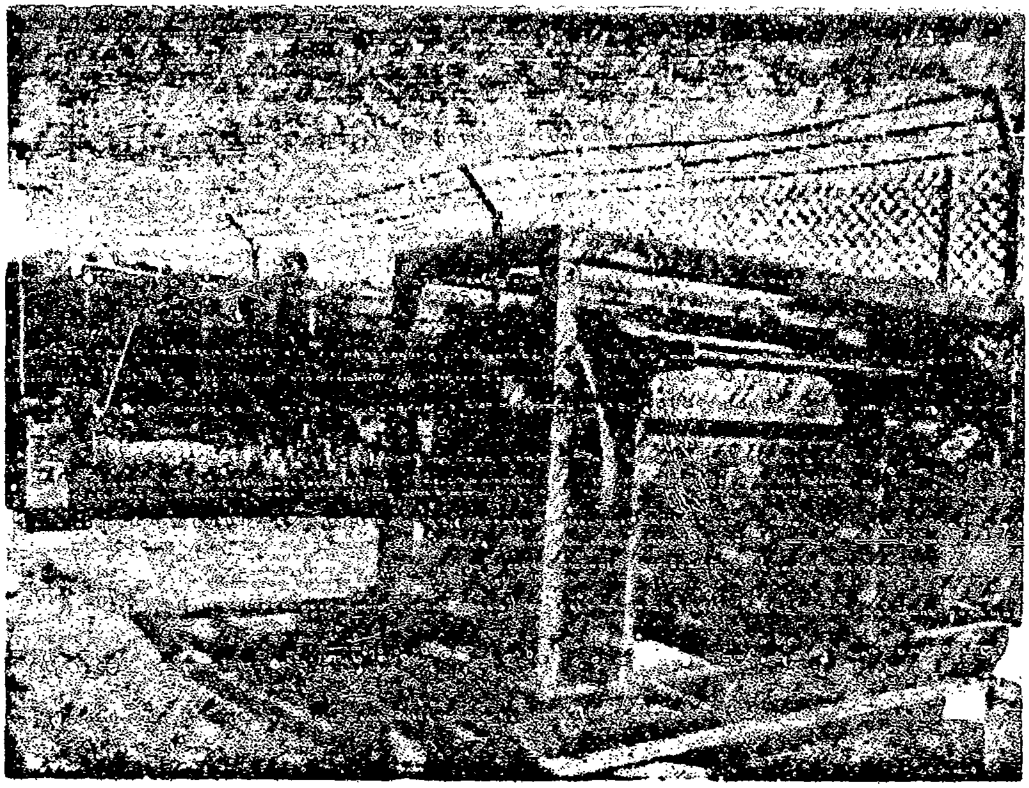

Figure 3. KMU-450 Filter/Blower System for air purification.

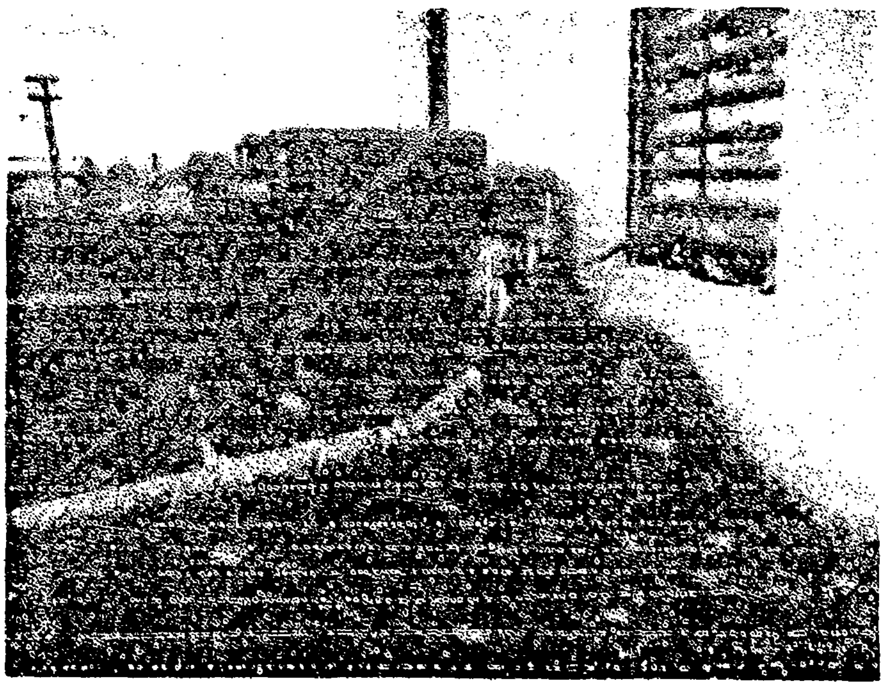

Figure 4. Air inlet box for filtered air distribution.

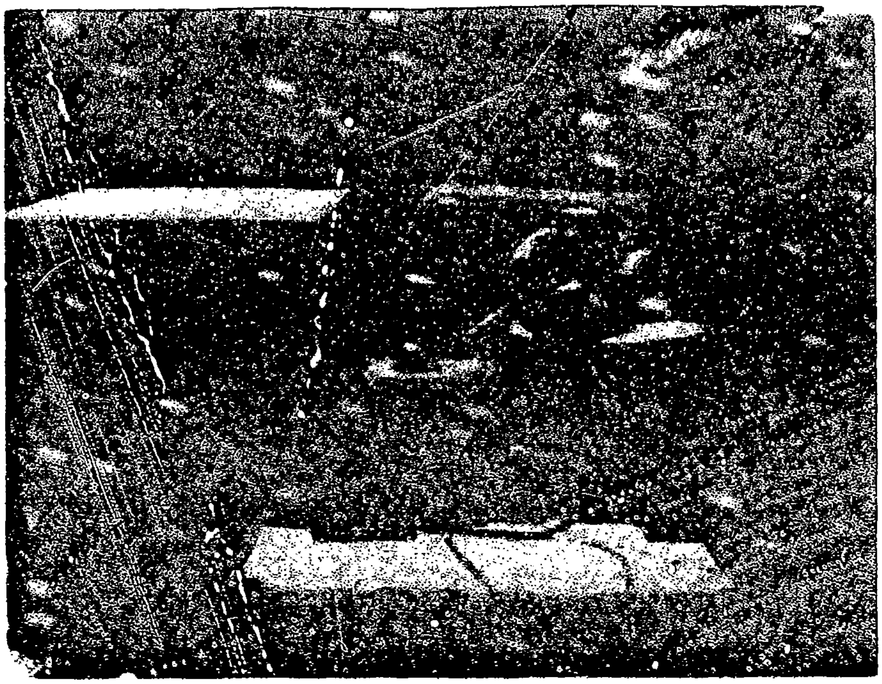

Figure 5. Filter/blower unit for recharge unit.

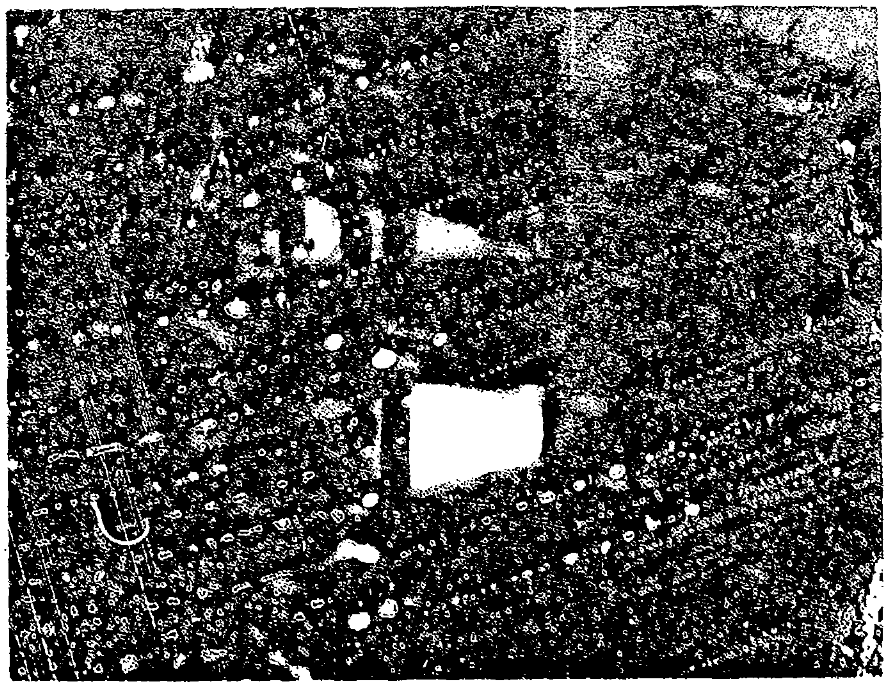

Figure 6. Twelve-bottle storage rack.

Figure 7. Eagle Charge Unit (Control Panel).

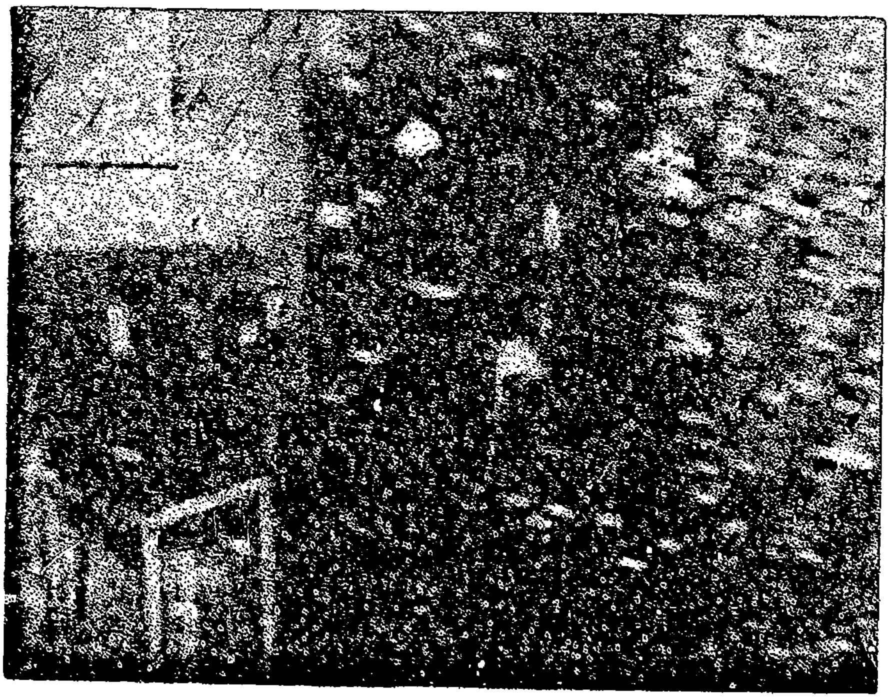

Figure 8. Eagle Charge Unit (bottle charge side).

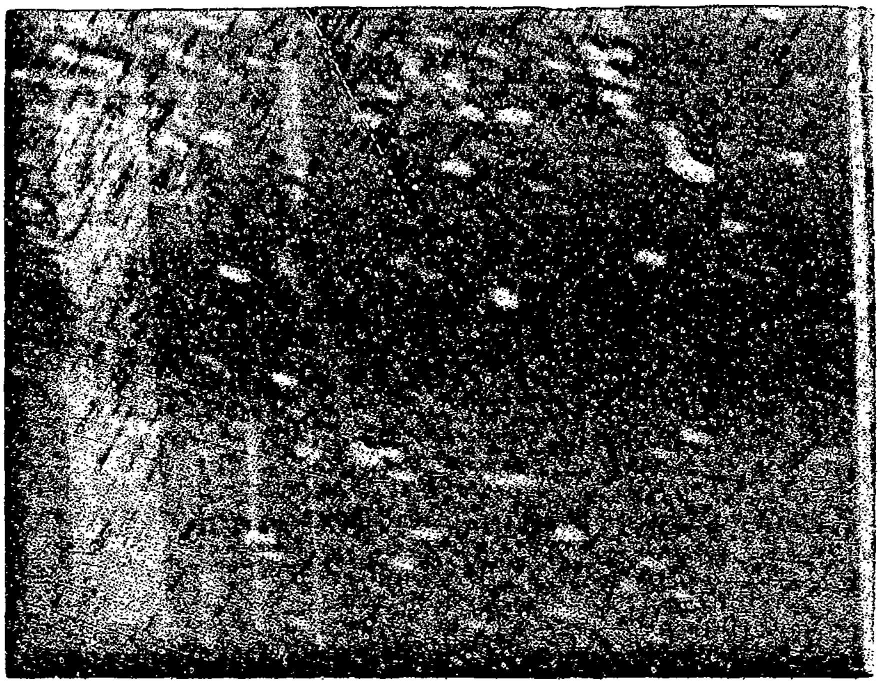

Figure 9. Trailer overall in vapor exposure area for test.

APPENDIX

FILLING PROCEDURE
FOR SCBA CYLINDERS

FILLING PROCEDURE FOR SCBA CYLINDERS

The compressor was brought to operating pressure (3500 psig) and the receiver was pressurized to a working pressure of 2500-2800 psig. The Model AD-800 filter unit was then pressurized and vented for approximately three minutes before releasing filtered breathing grade air to the cylinder servicing unit.

Six empty air tanks with valves covered with a polyethylene bag secured by a rubber band were placed in the storage rack, and the test was begun. Three empty cylinders were placed in the cylinder servicing unit, and the three service hoses of the cylinder servicing unit were loosened slightly. The servicing unit valve was opened slightly (by turning counterclockwise) until a slight air stream flowed through the service hoses. The top service hose was tightly secured to the filler valve of the top empty cylinder. This procedure was repeated for each of the two remaining cylinders in the servicing unit, thus providing three cylinders to be filled simultaneously. The valve on each cylinder was opened, and the steel safety door of the servicing unit was moved all the way to the right, isolating the cylinders to be filled and exposing the servicing unit valve and supply and cylinder pressure gauges. The servicing unit valve was slowly turned counterclockwise until the cylinder pressure was approximately 400 psig. When the cylinder pressure stabilized, the servicing unit valve was turned slowly counterclockwise until the cylinder pressure matched the supply pressure. This procedure was repeated until the cylinder pressure read approximately 2350 psig (the upper limit of the blue area of the cylinder pressure gauge). The servicing unit valve was turned all the way clockwise and the steel safety door was moved all the way to the left, again exposing the filled cylinders. The cylinder valve on each full cylinder was closed tight, and the bleed valve in the upper right-hand side of the top of the cylinder servicing unit was opened slightly to release line pressure. The service hose on each full cylinder was loosened slightly, and the servicing unit valve was turned counterclockwise slightly, allowing a slight air stream to escape around the service hose connections to the cylinders as in the loading operation above. As each service hose was removed from the full cylinder, the cylinder valve was covered with a clean polyethylene bag and the bag was secured with a rubber band and the service hose tightly attached to the retaining post. The full cylinders were removed from the cylinder servicing unit and were placed in the cylinder storage rack. The compressor was shut down and the cylinder service unit was vented through the cylinder bleed valve, which was then closed.

For purposes of this test, only three bottles were filled. The following tests were run: two series with no MeS (Blank #1 and Blank #2), three series with MeS in the cylinder filling area only (MeS #1 and MeS #2, and MeS #3), and three series with methyl salicylate in both the cylinder filling area and the compressor inlet area. MeS was supplied to the compressor inlet area from a 41.5 in. long x 26 in. wide x 2 in. (1.05 x 0.66 x 0.05 m) aluminum pan containing 3 pints of

MeS which was placed immediately under the compressor 30 min before the test (MeS #4, MeS #5, and MeS #6). The filled cylinders were removed and allowed to cool to room temperature, concluding the filling procedure.