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Evaluation of the Scott Aviation Portable Protective Breathing *Device for Contaminant Leakage* As Prescribed by FAA Action Notice A-8150.2

Office of Aviation Medicine
Washington, D.C. 20591

Phase I -- Original Tests of the *Portable Protective* Breathing Device

Phase II -- Tests of the Redesigned Portable Protective Breathing Device

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Final Report

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16. Abstract

At the request of Scott Aviation, performance tests of the crew portable protective breathing (CPBE) device (PN-802300-11) were conducted at ground level and 8,000 ft. altitude. The first tests at ground level measured contaminant leakage, oxygen and carbon dioxide levels, inhalation/exhalation pressures and internal/external dry-bulb temperatures; replications at 8,000 ft. were performed for all the variables except contaminant leakage. For ten male subjects, the device proved satisfactory for all measures tested; compliance with A-8150.2 could not be established for internal CPBE temperature since no wet-bulb values were obtained. Devices were also tested on nine female subjects; the findings were successful for all measures except contaminant leakage. A new set of tests, approved by the FAA Certification Office in New York, was conducted after changes in neck seal material and opening size were made by Scott Aviation, using only 1 male and 5 females with small neck circumferences (11.81 to 13.07 ins.) and 1 male with a large neck size (16.62 ins.). These tests proved successful for all but two devices on subjects with unusually protruding larynxes, for which a further reduction in neck seal opening size afforded adequate protection for these individuals, as well as an acceptable comfort level for a large individual. It is concluded that the Scott CPBE device with a 1/16" thick neoprene foam neck seal, having a 2.5" diameter opening, performs as required by FAA Action Notice A-8150.2 for the parameters measured.

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EVALUATION OF THE SCOTT AVIATION PORTABLE PROTECTIVE BREATHING DEVICE FOR CONTAMINANT LEAKAGE AS PRESCRIBED BY FAA ACTION NOTICE A-8150.2

PHASE I - Original tests of the Portable Protective Breathing Device

Introduction: A letter from Scott Aviation requesting support from the Civil Aeromedical Institute (CAMI) for contaminant leak testing of the Scott Aviation Crewmember Portable Protective Breathing (CPBE) Device, PN802300-11, was received by the CAMI Acting Manager, in November, 1987. Preliminary tests of the CPBE were conducted in January 1988, and it was determined that the n-pentane test system used for contaminant leak testing pursuant to TSO C-99, was not suitable for testing breathing devices in which the oxygen is chemically generated. Following the development of a new test system in which sulfur hexafluoride (SF_6) serves as the challenge gas, the CPBE were retested in August 1988.

Subjects: A total of eleven male and nine female subjects participated in the tests. Prior to the experiments all subjects received a medical examination, including an exercise stress test conducted using the workload profile for compliance with Action Notice A-8150.2. Heart rate, blood pressure, and electrocardiagram were monitored during the prescribed 15-minute test duration. The subjects who could not pass either the physical exam or the stress test were removed from participation in the experiment. Physical characteristics of the CPBE test subjects are provided in Table I.

Test Procedures: Tests of the devices for contaminant leaks, oxygen and carbon dioxide concentrations, inhalation-exhalation pressure, and inhalation temperature were conducted in the CAMI test chamber using the duration and workload profile described in FAA Action Notice A-8150.2. Two of the male subjects for which the CPBE passed the contaminant leak tests at ground level (about 1,300 ft in Oklahoma City) also participated in the altitude chamber tests at 8,000 feet simulated altitude for determinations of oxygen and carbon dioxide levels, inhalation-exhalation pressure, and inhalation temperature.

The actual CPBE test was conducted on a day subsequent to the physical exam and workload screen. Prior to testing, subjects were fully informed about the test procedures and objectives of the research, after which they executed informed consent. They then practiced the donning of the CPBE while wearing the required eyeglasses, and EKG electrodes were fitted for medical monitoring during the test. After being escorted to the test chamber, they were attached to the monitor by the EKG electrodes and a blood pressure cuff, the bicycle ergometer seat was adjusted to the correct height, the CPBE was donned and supplied with compressed air prior to the start of the 15-minute test, the chamber door was closed, and the level of atmospheric SF_6 was brought to about one

TABLE I

Physical Characteristics of Test Subject Population

Subject (no.)	Age (yrs)	Height (ins.)	Weight (lbs.)	Neck Circ. (ins.)
M-1	24	71.25	187.00	16.07
M-2	25	68.00	150.25	N/A
M-3	33	70.00	150.50	N/A
M-4	24	74.50	189.00	14.72
M-5	33	69.00	163.75	12.68
M-6	22	74.25	156.50	14.53
M-7	20	69.00	145.75	15.52
M-8	31	73.00	227.00	16.62
M-9	26	71.50	127.50	14.26
M-10	26	71.00	169.25	14.53
M-11	34	68.00	146.75	15.24
F-2	18	61.50	122.25	12.68
F-3	35	65.12	104.75	11.58
F-4	29	63.00	153.25	14.02
F-5	29	63.36	107.50	12.40
F-6	35	69.75	128.00	12.68
F-7	20	66.60	135.25	12.17
F-8	35	69.36	141.25	12.68
F-9	21	66.50	111.50	11.81
F-10	29	64.00	109.50	N/A

N/A indicates that the measurement was not available

percent (1%) of the test chamber volume. At this time the subject was told to pull the pin to start the internal flow of oxygen within the CPBE and begin pedalling the bicycle ergometer at the beginning workload level. Once this was accomplished, the external air supply to the CPBE was interdicted and the test begun. The test continued for the next 15 minutes at the workload prescribed in Action Notice A-8150.2, i.e.:

0 to 05 minutes at 0.33 watts/lb body weight
5 to 07 minutes at 0.66 watts/lb body weight
7 to 12 minutes at 0.50 watts/lb body weight
12 to 14 minutes at 0.66 watts/lb body weight
14 to 15 minutes at 0.33 watts/lb body weight

In an effort to create head movements and talking as directed by TSO C-99, subjects moved their heads slowly from side to side (as

though scanning instruments) during the seventh minute, moved their heads up and down during the tenth minute, and recited the English alphabet aloud during the 13th minute of the test.

Heart rate and EKG were monitored continuously, and blood pressure periodically, for subject safety. Air from inside the CPBE was sampled at six sites on the visor via tubes attached by "Swage-lok" connectors. Rubber gaskets sealed these connections on both the inside and outside of the visor. On the left side of the CPBE visor, one sample tube was placed near the top and one near the bottom for sampling SF6 within the CPBE. In the center near the nose and mouth were three sampling sites; the top site held a probe for measuring internal oxygen and carbon dioxide levels, the bottom site had a transducer for measuring inhalation-exhalation pressures, and the center site housed a copper-constantan thermo-couple used to measure temperature. There was no measure of relative humidity; therefore, only dry bulb temperatures were obtained.

Two Perkin-Elmer Medical Gas Analyzers (MGA/mass spectrometers) were used to measure the SF6, oxygen, and carbon dioxide levels. One was used to monitor SF6 concentrations; the test chamber SF6 level was monitored during the first 45 seconds of each minute, then upper visor, outside laboratory, and lower visor samples were obtained for 5 seconds each during the final 15 seconds of each minute. The oxygen and carbon dioxide levels within the CPBE were measured continuously using the second Perkin-Elmer MGA.

Results: Initial tests of the CPBE proved successful for 10 of 11 male subjects; the CPBE on subject M-5 failed the test by exceeding the 5% contaminant leak testing criterion. However, as shown in Table I, subject M-5 had the smallest neck size of all the male subjects. In addition, for only one of the nine females, subject F-8, did the CPBE pass the contaminant leak test. Except for subject F-4, the females all had neck sizes as small as M-5 (see Table I), thus, the size of the CPBE neck opening proved to be the most significant factor in the leak tests. These results prevented the CPBE from attaining the overall success required for certification. The graphs of individual CPBE SF6 leakage levels are presented in Appendix A, pages A-2 through A-12.

The oxygen levels within the CPBE were greater than the 21% ambient air concentration during the first minute of the test and increased thereafter. These data are available, but are not presented, because all of the values exceeded the requirement substantially.

The carbon dioxide levels within the CPBE were also consistently within the prescribed limits. Although these data were more variable than those for oxygen, the required 15-minute ground-level mean of 4%, and the 5% maximum for no more than 2 minutes, were not exceeded. The results of the carbon dioxide measurements are provided in Table II as percentages, and for two subjects, graphs are also presented which show the carbon dioxide values in both percent (page A-14), and partial pressure (page A-15).

TABLE II

Percent Carbon Dioxide for Ground Level Tests

Minute	Subject No.									
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	M-10
1	0.90	1.24	1.04	1.39	0.93	1.16	0.81	0.75	0.88	0.99
2	0.98	1.21	1.09	2.23	1.13	1.40	0.83	0.81	0.96	1.04
3	1.01	1.24	1.05	2.48	1.91	1.55	0.93	0.91	1.27	1.16
4	1.24	1.35	1.08	2.53	1.31	1.46	0.91	1.05	1.07	0.98
5	1.64	1.38	1.06	2.49	1.11	1.44	0.86	.88	0.88	1.24
6	1.63	1.48	1.25	2.28	1.54	1.61	----	1.14	0.95	1.34
7	1.74	1.70	1.55	2.51	2.10	1.63	----	1.28	0.96	1.56
8	1.89	1.89	1.30	2.75	2.14	1.63	----	1.39	1.03	1.69
9	2.08	1.90	1.25	2.63	1.64	1.94	----	1.32	0.98	1.46
10	1.76	1.71	1.29	2.25	2.46	2.46	----	1.18	0.98	1.39
11	1.88	2.03	1.41	2.26	2.10	2.48	0.93	1.21	1.00	1.41
12	1.80	1.86	1.16	2.24	3.70	2.78	0.94	1.20	1.04	1.44
13	2.14	1.82	1.52	2.45	2.03	3.08	0.96	1.21	1.16	1.20
14	2.48	1.98	1.78	3.15	2.55	3.00	0.86	1.64	1.64	2.08
15	2.75	1.84	1.79	3.30	2.50	3.09	1.32	1.74	1.44	2.87

	M-11	F-2	F-3	F-4	F-5	F-6	F-7	F-8	F-9
1	1.13	1.14	.74	1.00	1.63	1.65	0.81	1.51	0.84
2	1.33	.84	1.23	1.04	0.80	1.61	2.15	1.19	0.90
3	1.25	.84	1.54	1.21	0.86	1.68	2.36	1.23	0.95
4	1.11	1.19	1.61	1.25	0.88	1.70	1.86	1.23	0.98
5	0.82	.96	1.75	1.05	----	1.86	1.74	1.06	1.09
6	0.81	1.69	1.71	1.16	----	2.30	1.75	1.29	
7	1.03	2.40	----	----	----	----	2.10	1.51	----
8	1.53	2.51	----	----	----	----	4.72	1.58	----
9	1.23	2.73	----	----	----	----	4.82	1.66	----
10	1.30	----	----	----	----	----	----	1.71	----
11	1.25	----	----	----	----	----	----	1.73	----
12	1.04	----	----	----	----	----	----	1.80	----
13	1.23	----	----	----	----	----	----	1.55	----
14	1.38	----	----	----	----	----	----	2.00	----
15	1.63	----	----	----	----	----	----	2.23	----

The maximum and minimum internal CPBE pressures at ground level were well within the prescribed limit of 3.5 inches of water of breathing resistance. These data are presented in Table III for all subjects except F-10.

TABLE III

Maximum and Minimum Internal CPBE Pressure in Inches of H20

Subj.	Max.	Min.	Subj.	Max.	Min.
M- 1	0.8	-0.6			
M- 2	1.0	-0.3	F- 2	0.5	-0.2
M- 3	0.2	-0.3	F- 3	0.4	-0.1
M- 4	0.5	-0.4	F- 4	0.4	-0.4
M- 5	1.0	-0.6	F- 5	0.8	-0.4
M- 6	0.9	-0.3	F- 6	0.7	-0.3
M- 7	1.2	-0.5	F- 7	0.4	-0.2
M- 8	0.8	-0.6	F- 8	0.5	-0.4
M- 9	0.6	-0.4	F- 9	0.2	0.0
M-10	0.8	-0.7	F-10	N/A	N/A
M-11	0.7	-0.3			

N/A indicates that these data are not available

Since only dry-bulb temperature measurements were obtained, no assessment of compliance with the 50o F wet-bulb temperature requirement of A-8150.2 42 could be made. The internal CPBE dry-bulb temperature data are presented in Table IV. Recall that two subjects were tested at both ground level and 8,000 feet altitude; the temperatures at altitude were lower than at ground level. Graphs of the internal CPBE temperature for those two subjects are presented on page A-13 in the appendix.

Discussion: The results from these tests indicated that except for contaminant leakage, the Scott Aviation CPBE (PN-802300-11) met the performance requirements of Action Notice A-8150.2. Oxygen and carbon dioxide levels, as well as inhalation-exhalation pressures were all acceptable, and the dry-bulb temperatures suggested compliance with the wet-bulb requirements, as well.

TABLE IV

Internal CPBE Temperature (deg C)

Minute	Subject No.									
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	M-10
0	23.6	31.2	27.0	28.2	27.6	27.0	28.4	29.6	29.0	27.6
1	28.6	31.2	27.6	29.2	27.8	27.6	28.6	29.6	29.6	28.0
2	31.2	32.8	29.0	30.4	29.2	28.8	30.2	32.0	30.8	29.0
3	33.4	35.0	31.4	32.4	30.6	29.8	31.8	33.6	32.2	29.6
4	36.0	35.8	33.4	34.8	31.6	32.4	33.0	36.0	34.0	31.8
5	38.2	37.0	35.2	36.6	33.0	34.8	34.6	37.6	35.2	33.6
6	39.0	38.2	36.0	38.4	34.8	36.2	36.0	39.6	36.4	35.6
7	40.2	39.0	38.2	40.4	36.2	38.4	37.4	40.6	36.6	36.8
8	41.2	39.4	39.6	41.4	38.0	39.0	38.8	41.4	38.8	38.6
9	41.4	39.8	40.4	41.6	38.8	40.0	39.6	42.4	39.6	39.6
10	42.6	40.6	41.0	42.6	39.6	40.2	40.4	42.8	40.2	40.4
11	43.4	40.8	42.2	43.2	40.0	40.2	41.4	43.6	41.8	41.0
12	43.6	42.4	42.8	43.6	41.4	40.4	42.6	44.4	42.4	41.4
13	44.0	41.6	43.0	44.8	42.0	40.6	43.6	44.4	43.8	41.4
14	43.6	43.0	44.4	46.0	41.6	41.4	45.6	45.4	44.0	42.6
15	44.6	43.4	45.4	47.4	43.6	41.0	48.4	45.2	45.4	42.0

	M-11	F-2	F-4	F-5	F-6	F-7	F-8	F-9	F-10
0	30.0	27.6	27.6	27.4	28.2	29.2	28.4	27.6	28.0
1	30.0	28.0	28.0	28.0	28.6	29.4	29.4	28.2	27.8
2	31.6	29.4	29.8	29.6	30.0	30.6	31.2	29.0	28.6
3	32.8	31.6	31.0	30.4	31.0	31.4	32.6	29.6	29.4
4	33.6	32.4	33.6	32.0	32.6	33.0	34.2	31.0	30.6
5	34.6	34.0	35.6	----	33.2	33.6	35.8	32.2	----
6	36.0	35.6	37.6	----	34.4	35.2	37.4	----	----
7	37.6	37.0	----	----	----	37.0	38.6	----	----
8	38.4	38.4	----	----	----	38.0	40.6	----	----
9	39.0	39.4	----	----	----	38.8	41.8	----	----
10	39.2	----	----	----	----	----	42.6	----	----
11	40.4	----	----	----	----	----	43.0	----	----
12	40.8	----	----	----	----	----	44.6	----	----
13	42.0	----	----	----	----	----	46.4	----	----
14	42.0	47.0	----	----	----	----	----	----	----
15	42.0	48.0	----	----	----	----	----	----	----

The contaminant leakage problems for persons with smaller neck sizes indicated that a general reduction in the size of the CPBE neck opening might prove beneficial, although the male subject for which the CPBE failed reported that at approximately the time of failure he had shrugged his shoulders and felt a rush of cool air on the right side of his face. This suggests a problem with the ability of the neck seal to return to its original size and shape after the neck seal is stretched when donning the CPBE, further suggesting that the neck seal material was not pliable enough.

These considerations led Scott Aviation to redesign the CPBE, incorporating changes in neck seal material and opening size, to overcome the contaminant leakage problems.

PHASE II - Tests of the Redesigned Portable Protective Breathing Device

Introduction: It was determined in Phase 1 testing that the Scott Aviation Crewmember Portable Protective Breathing (CPBE) Device (PN 802300-11) did not provide adequate protection against inward contaminant leakage for individuals with small neck circumferences (eight of nine female and one of eleven male test subjects). At the request of Scott Aviation, we conducted another test of the same device, modified only by the installation of a new neck seal; this modification changed the Scott part number (PN 802300-14). After concurrence with the FAA Aircraft Certification Office in New York, only a limited number of devices were tested, using subjects with small neck circumferences similar to those who failed with the original neck seal. Scott Aviation also requested that we test, in the presence of their project engineer, two devices with the original neck seal to assure them that the device was, in fact, ineffective because of inward contaminant leakage around the neck seal.

Subjects: All subjects were medically screened and informed about the procedures and purposes of the research prior to the tests in a manner identical to that for the Phase I tests. At that time they executed informed consent. Again, those who could not pass either the physical exam or the exercise stress test were not allowed to participate in the actual tests of the CPBE. After the screening, each subject was then scheduled for the experimental tests on a subsequent day. The physical and respiratory characteristics of the subjects who participated in this phase of the study are shown in Table V.

Test Procedures: Tests of the devices for contaminant leaks, oxygen and carbon dioxide levels, inhalation/exhalation pressure, and inhalation temperature were conducted in the CAMI test chamber at the duration and workload profile prescribed by FAA Action Notice A-8150.2 in a manner identical to that used for phase I.

Although all the data for all parameters tested are available upon request, only the results of the contaminant leak portion of the test are reported here, since only that parameter was left in question from Phase I. All tests were conducted at ground level (about 1,300 ft), since the altitude chamber tests were conducted successfully during the original experiment (phase I). Recall that heart rate and EKG were monitored continuously, and blood pressure periodically, during the tests for subject safety. The workload schedule for the 15-minute duration progressed as prescribed in the Action Notice, i.e.:

0 to 05 minutes at 0.33 watts/lb body weight
5 to 07 minutes at 0.66 watts/lb body weight
7 to 12 minutes at 0.50 watts/lb body weight
12 to 14 minutes at 0.66 watts/lb body weight
14 to 15 minutes at 0.33 watts/lb body weight

TABLE V

Physical Characteristics of Test Subject Population

Subj. (No.)	Age (Yrs)	Hgt. (in)	Wgt. (lb)	Neck Circ. (in)	FVC (l)	%	FEV1 (l)	%
M-1	31	73	228	16.62	6.2	106	5.2	109
M-2	33	69	163	13.07	5.7	116	3.7	92
M-3	25	68	150	15.95	5.7	112	4.6	110
F-1	36	69	130	12.68	4.6	118	3.3	105
F-2	19	67	142	12.68	4.4	112	3.4	97
F-3	24	59	109	11.81	3.4	106	2.8	103
F-4	32	65	122	12.17	4.1	113	3.2	106
F-5	19	67	148	12.76	4.5	112	3.9	107

FVC = Forced Vital Capacity;
(%) = Pred FVC (Percent of Predicted)
FEV1 = Forced Expiratory Volume in First Second;
(%) = Pred FEV1 (Percent of Predicted)
FVC & FEV1 based on age, height, and weight

Results: The original CPBE neck seals were constructed of 0.003" polyurethane film with a 3.25" diameter neck opening, whereas the new neck seals were constructed of 1/16" neoprene foam with a 2.75" diameter neck opening. The initial test subject sample consisted of the one male for whom the original device failed, five females with neck circumferences ranging from 11.81 to 12.76 inches, and one male with a large neck circumference (16.62 in.) to test for comfort and ease of donning.

In addition to the others parameters tested, the new neck seal was effective in providing contaminant leak protection for subjects M-1, F-1, F-2, F-3, and F-5 (Appendix B pages 2-6). However, it was not effective for subjects M-2 and F-4 (Appendix B pages 7 and 8), although both of these subjects had larger neck sizes than subject F-3.

The apparent reason for contaminant leakage for these two subjects was related more to anatomical structure rather than size. Both of these subjects had significantly protruding larynxes, which caused small channels alongside the larnyx through which the SF6 could enter. To overcome this problem, Scott decided to reduce the size of the neck seal opening to a 2.5" diameter. Since the 2.75" diameter CPBE opening had already passed the leak test on the subject with the smallest neck circumference, only those two individuals for whom anatomically-related failures were recorded were retested for contaminant leakage, although subject M-3, with a large neck size (15.95 in.), was tested for the impact the smaller neck seal opening had on comfort and fit. These last tests were conducted using identical procedures to those used before. The results of these contaminant leak tests are provided in Appendix B (pages 9, 10, and 11). As indicated, reducing the neck seal opening to 2.5" was adequate to provide contaminant leak protection for these last subjects, but subject M-3 did indicate that the neck seal felt tight and uncomfortable, although not unbearable.

Discussion: The results from the Phase II tests indicated that the Scott Aviation CPBE (PN-802300-11) with the redesigned neck seal met all the performance requirements of Action Notice A-8150.2, as tested. Contaminant leakage, oxygen and carbon dioxide levels, and inhalation-exhalation pressures were all acceptable, and the dry-bulb temperatures again suggested compliance with the wet-bulb requirements.

The contaminant leakage problems for persons with smaller neck sizes were generally alleviated by the selection of the neoprene foam neck seal, with the 2.75" opening, which had a better "memory" for its original configuration, although the particular anatomical conformation of the larynx in a small neck made the further reduction in neck opening size to 2.5" a necessity.

It is concluded that the Scott CPBE with the neck seal made of 1/16" neoprene foam with a 2.5" diameter opening is adequate to perform as required in FAA Action Notice A-8150.2.

References:

1. FAA Action Notice 8150.2, " Guidance for Approval of Crewmember Protective Breathing Equipment," September 1, 1987.

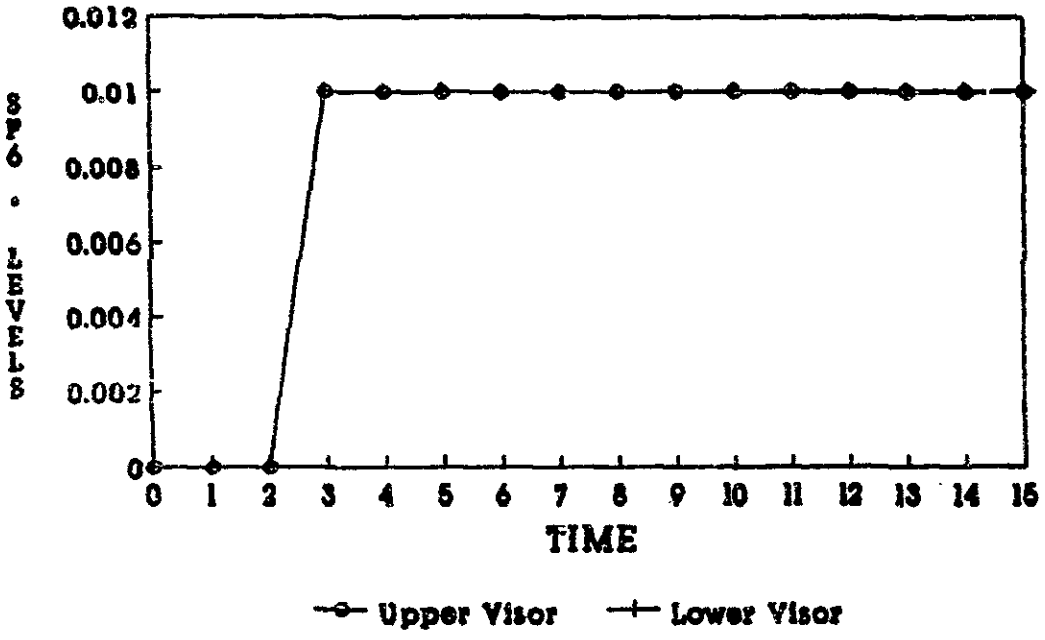
2. FAA Technical Standard Order (TSO)-C99, "Protective Breathing Equipment," June 27, 1983.

3. Society of Automotive Engineers Aerospace Standard 8031, "Personal Protective Devices for Toxic and Irritating Atmospheres. Air Transport Crew Members," June 1980.

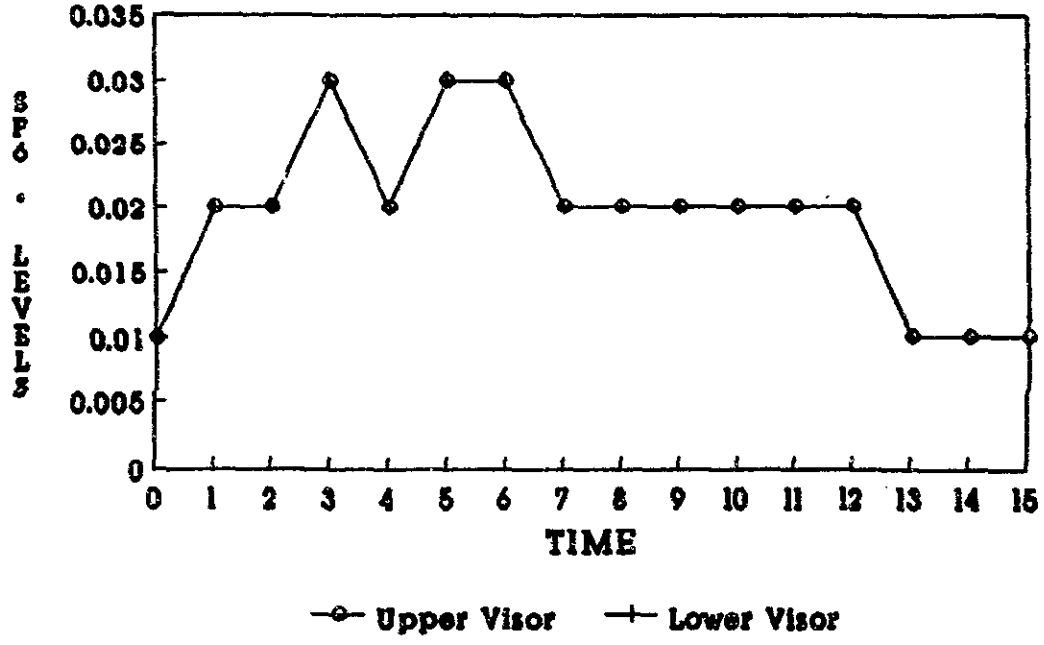
Appendix A

*SF6 levels are presented as the concentration within the hoods. To determine the percentage of the 1 % chamber concentration, multiply the concentration by 100.

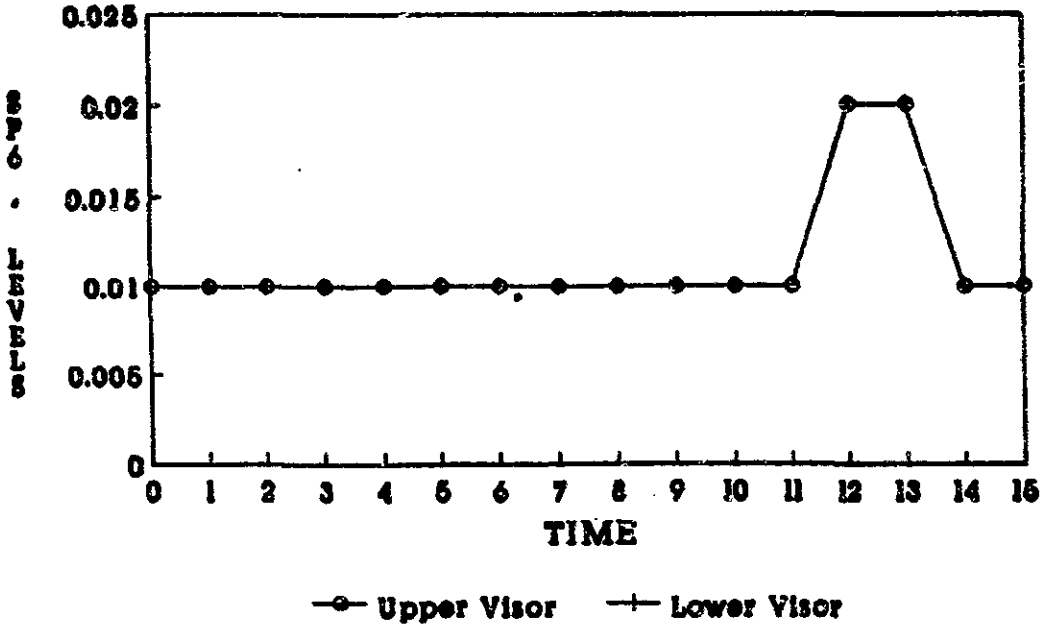
CONTAMINANT LEAKAGE
SUBJECT M-1



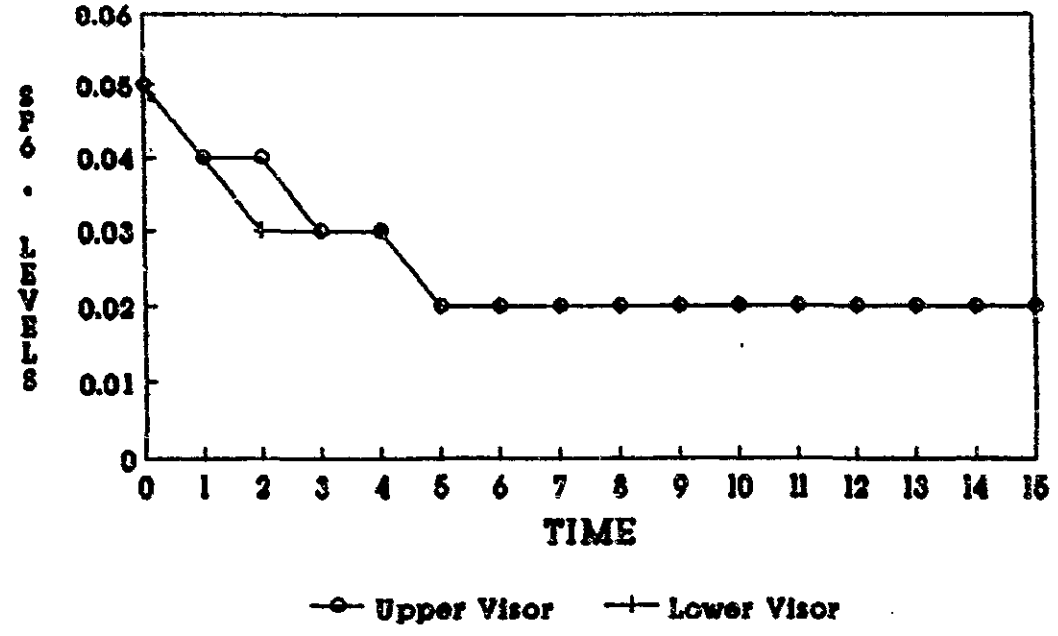
CONTAMINANT LEAKAGE
SUBJECT M-2



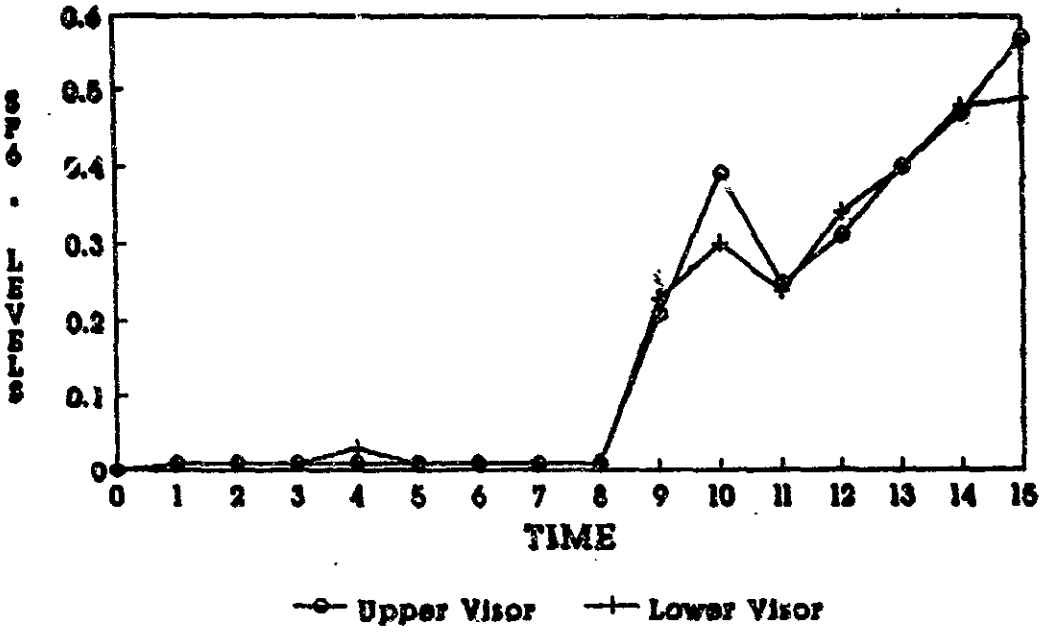
CONTAMINANT LEAKAGE
SUBJECT M-3



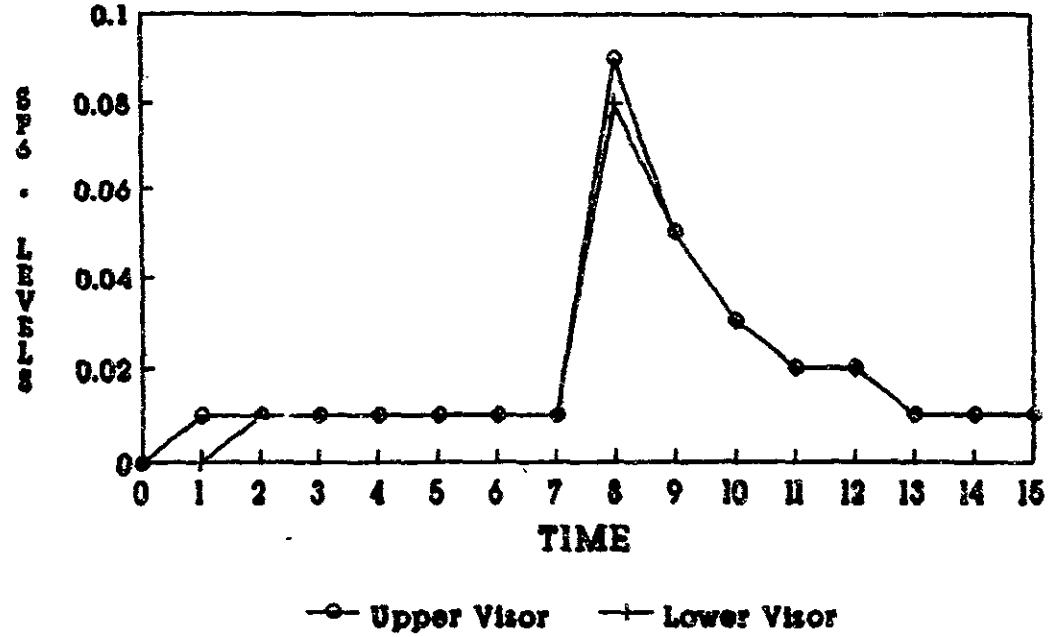
CONTAMINANT LEAKAGE
SUBJECT M-4



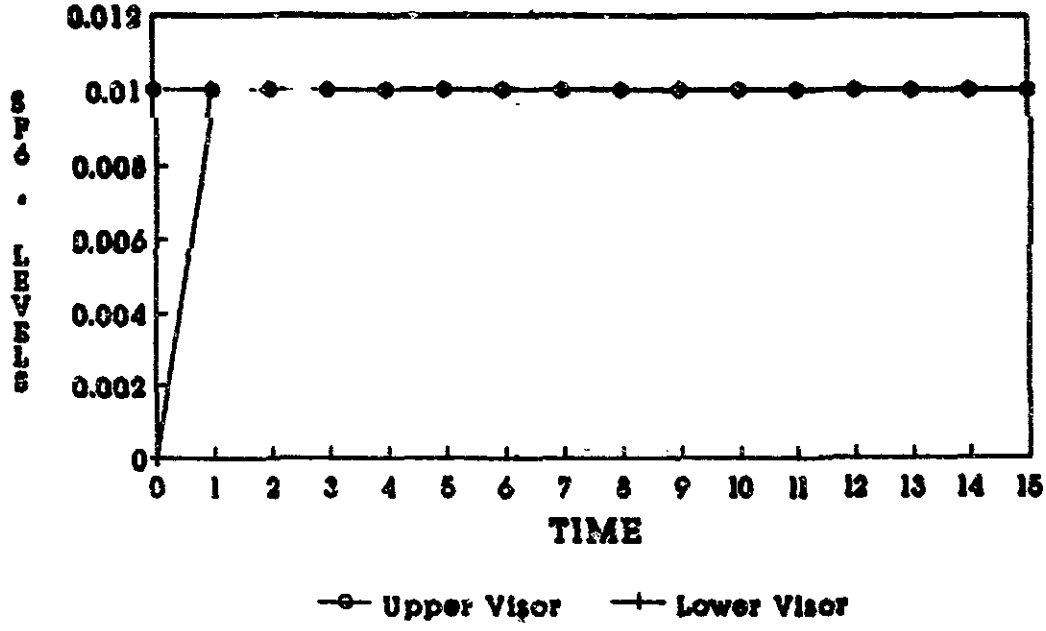
CONTAMINANT LEAKAGE
SUBJECT M-6



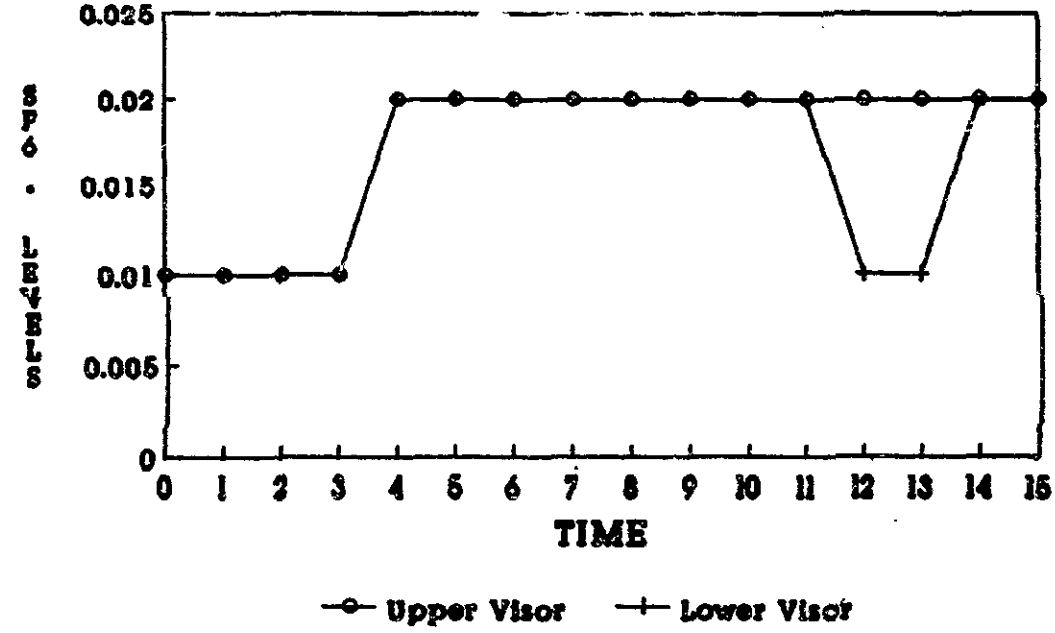
CONTAMINANT LEAKAGE
SUBJECT M-6



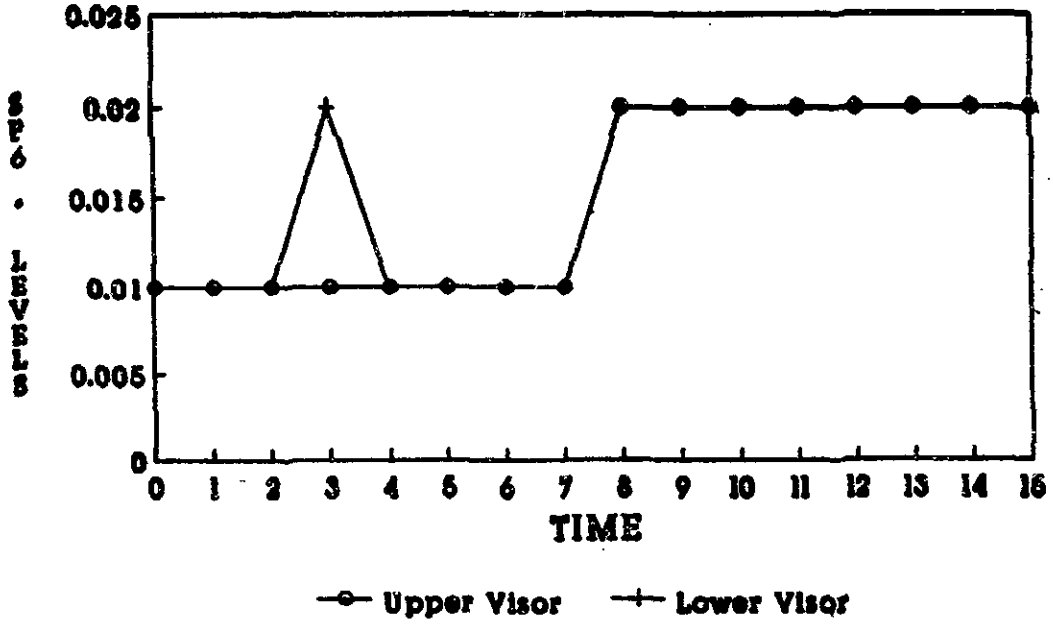
CONTAMINANT LEAKAGE
SUBJECT M-7



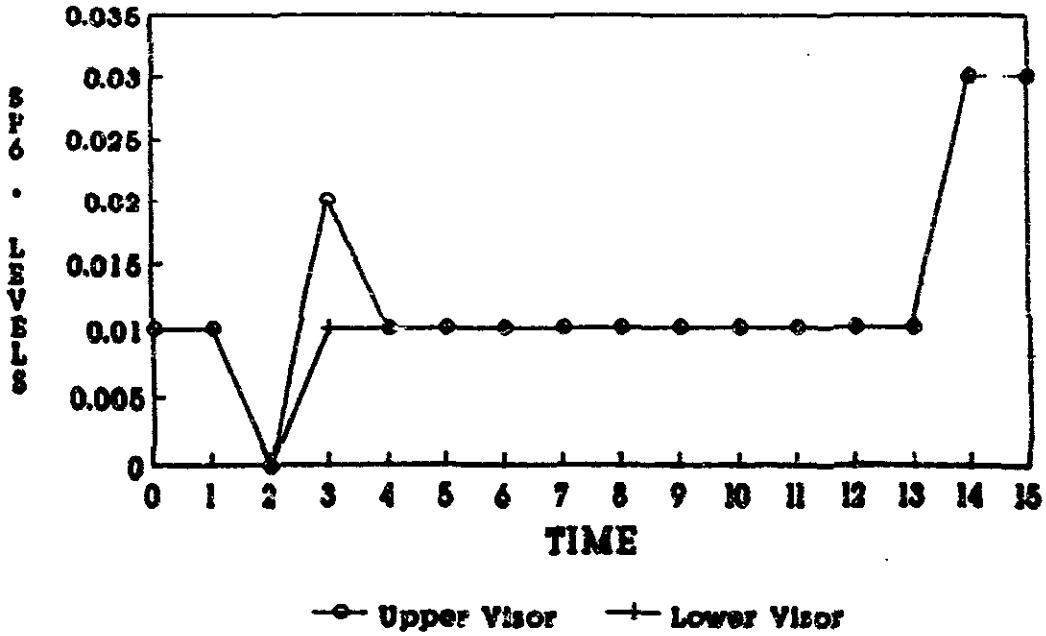
CONTAMINANT LEAKAGE
SUBJECT M-8



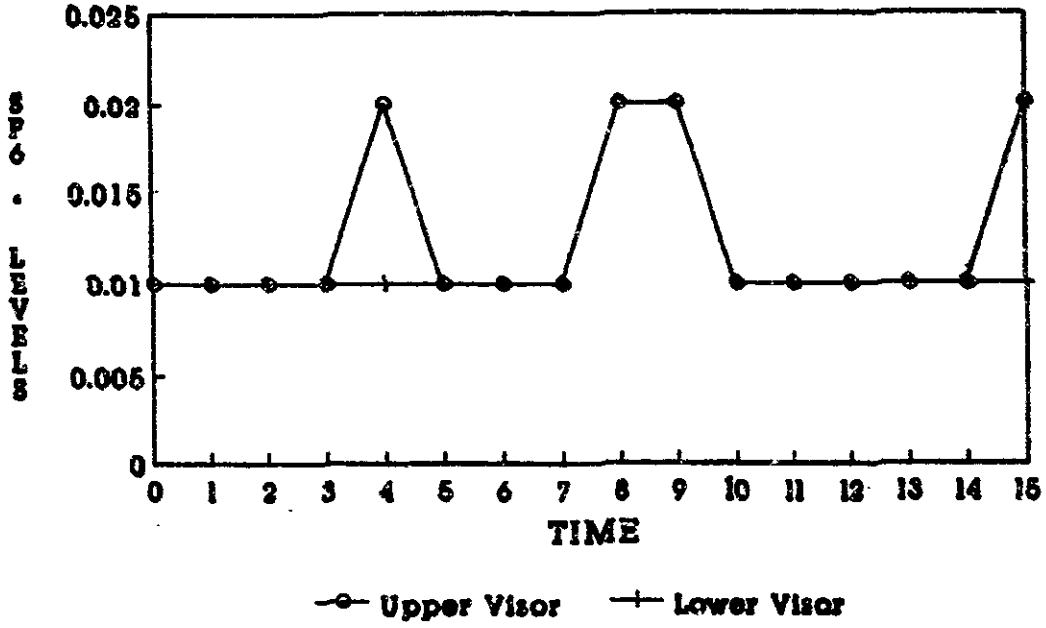
CONTAMINANT LEAKAGE
SUBJECT M-9



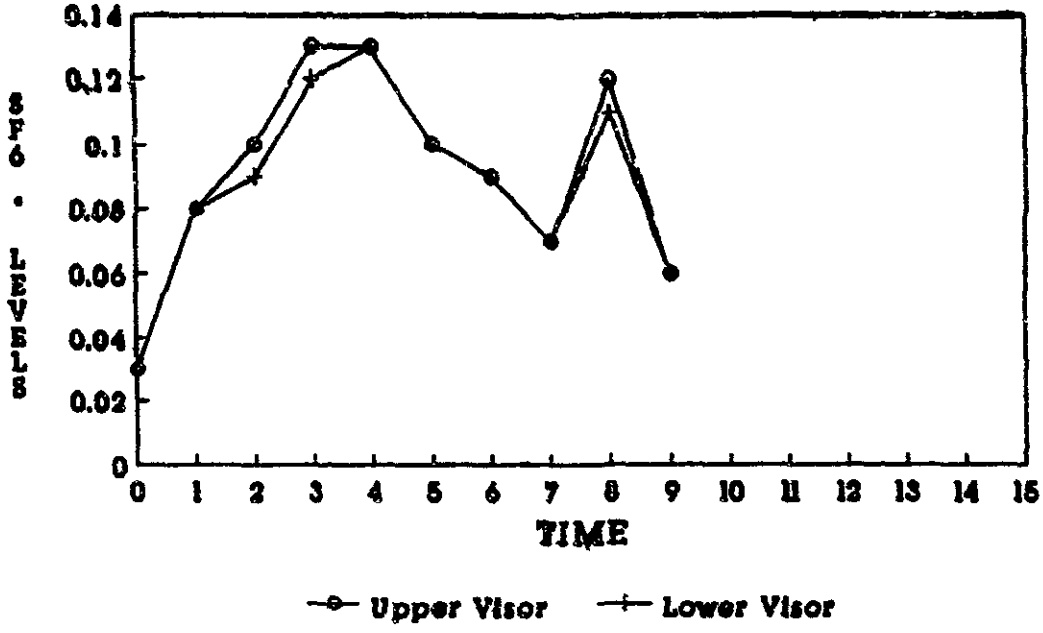
CONTAMINANT LEAKAGE
SUBJECT M-10



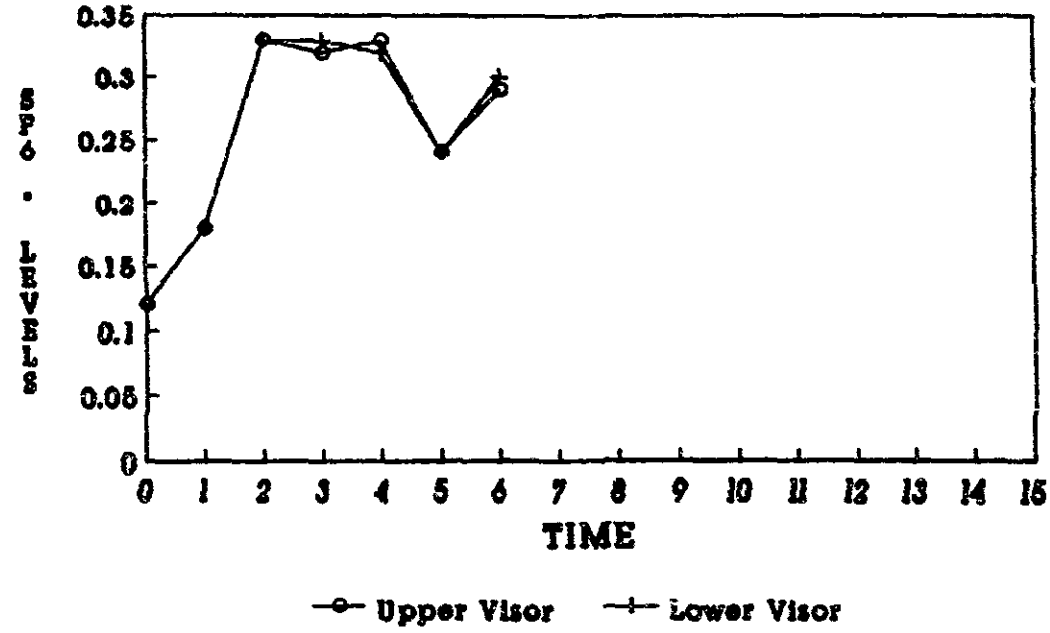
CONTAMINANT LEAKAGE
SUBJECT M-11



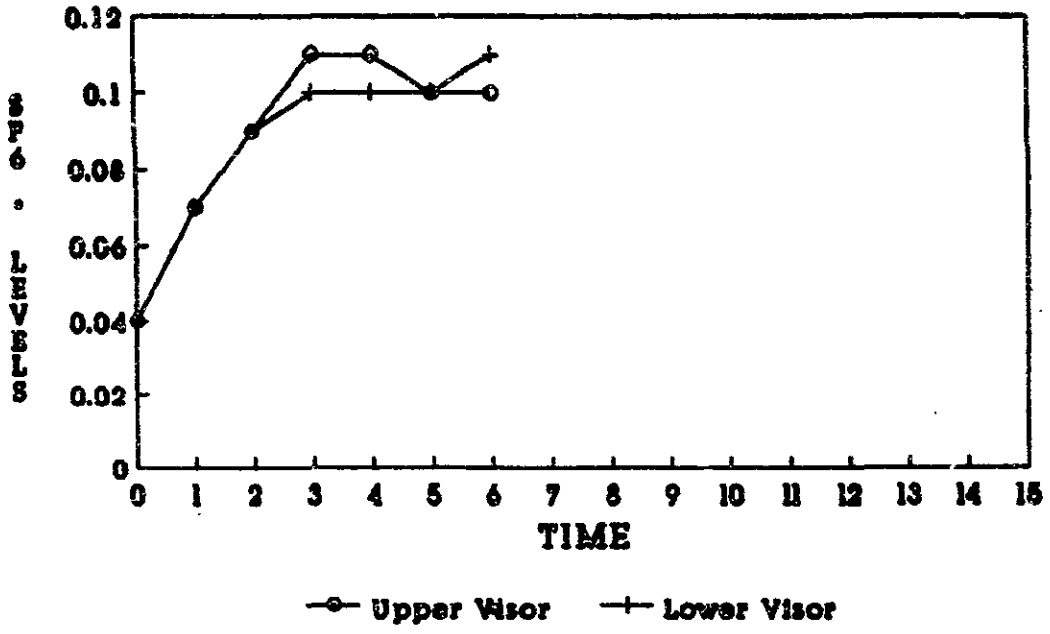
CONTAMINANT LEAKAGE
SUBJECT F-2



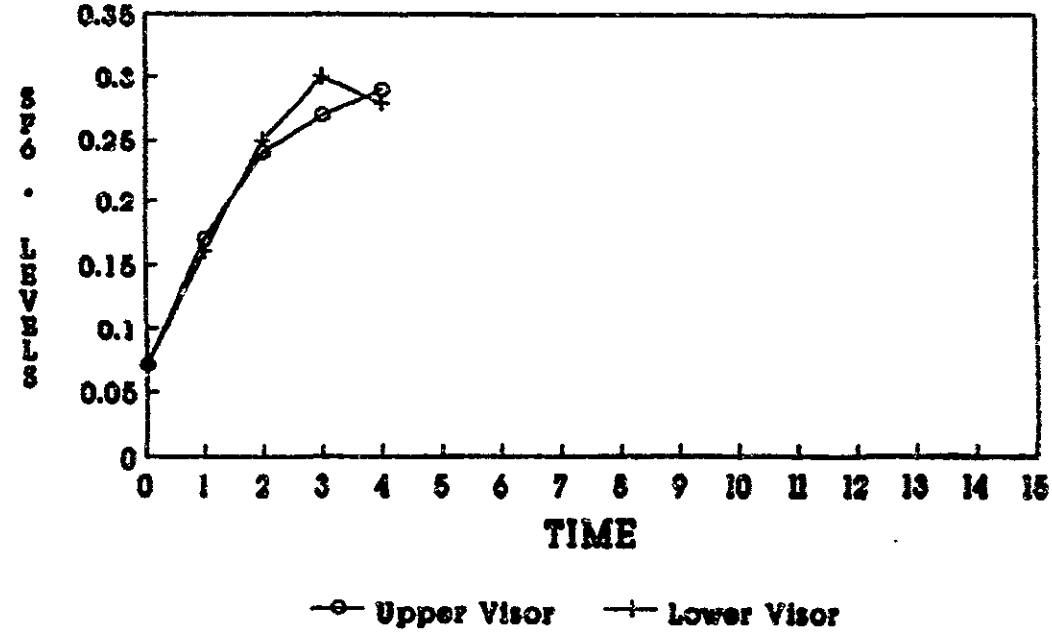
CONTAMINANT LEAKAGE
SUBJECT F-3



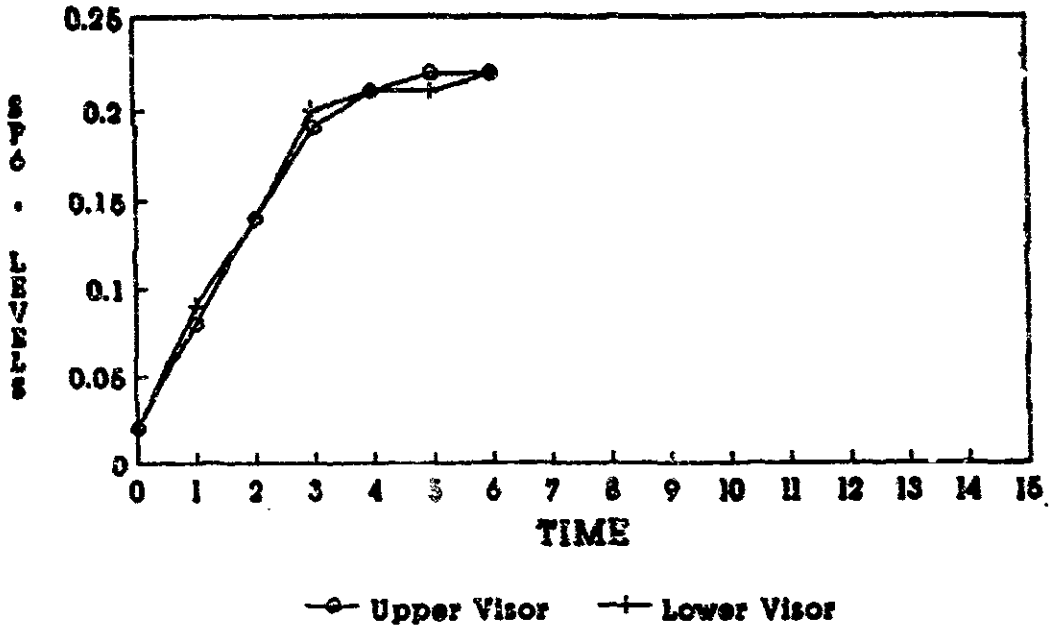
CONTAMINANT LEAKAGE
SUBJECT F-4



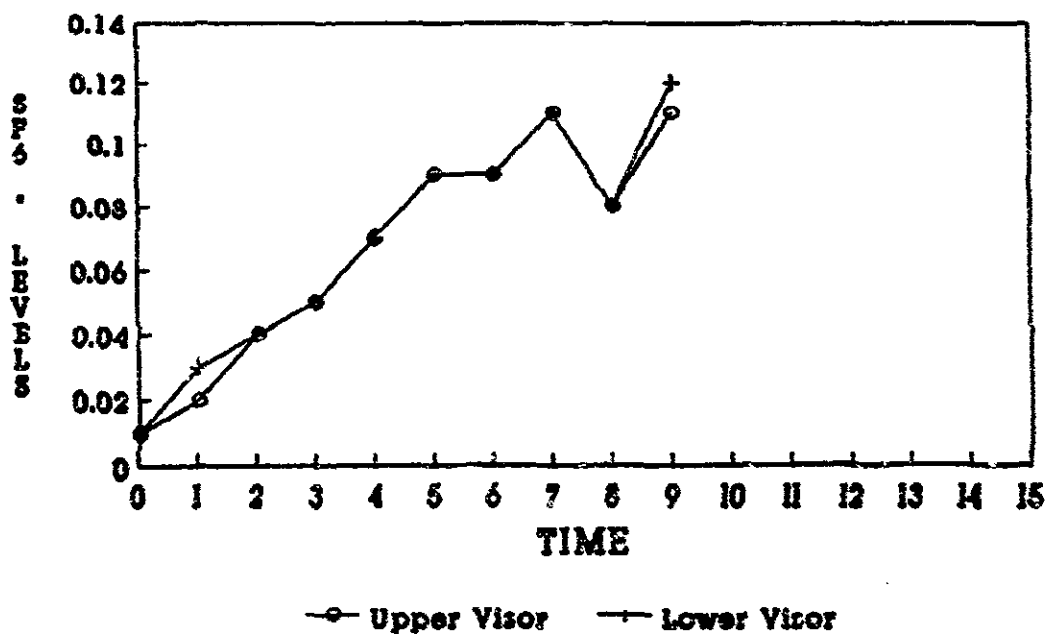
CONTAMINANT LEAKAGE
SUBJECT F-5



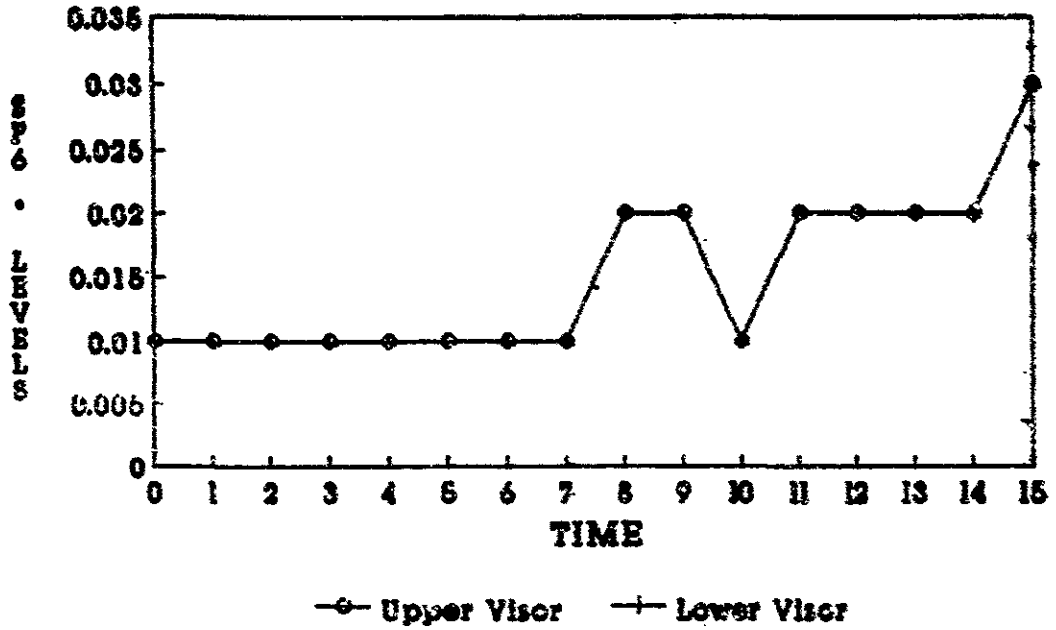
CONTAMINANT LEAKAGE
SUBJECT F-6



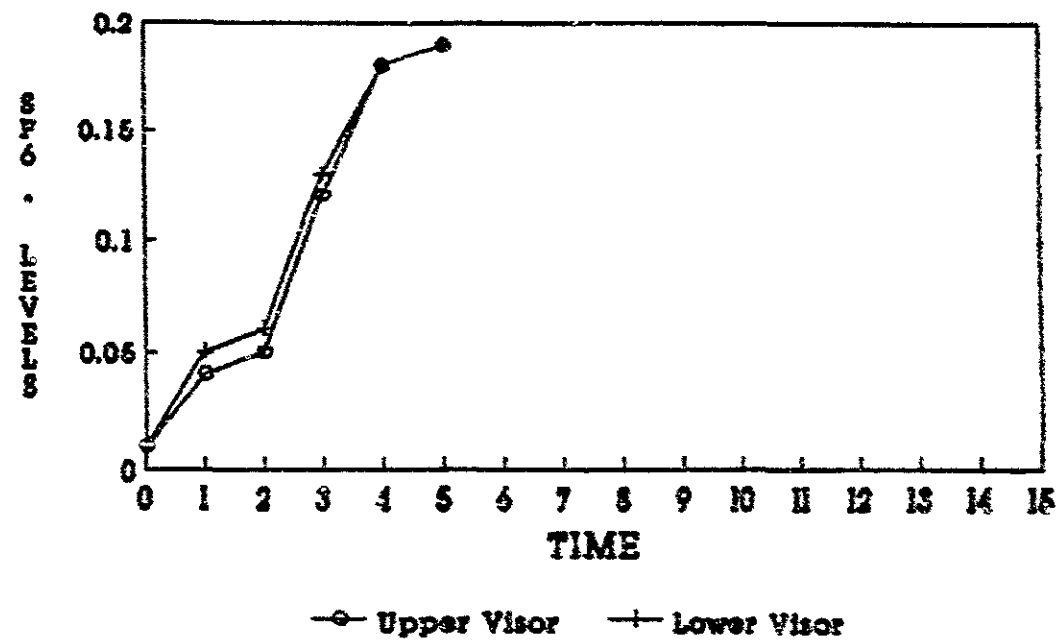
CONTAMINANT LEAKAGE
SUBJECT F-7



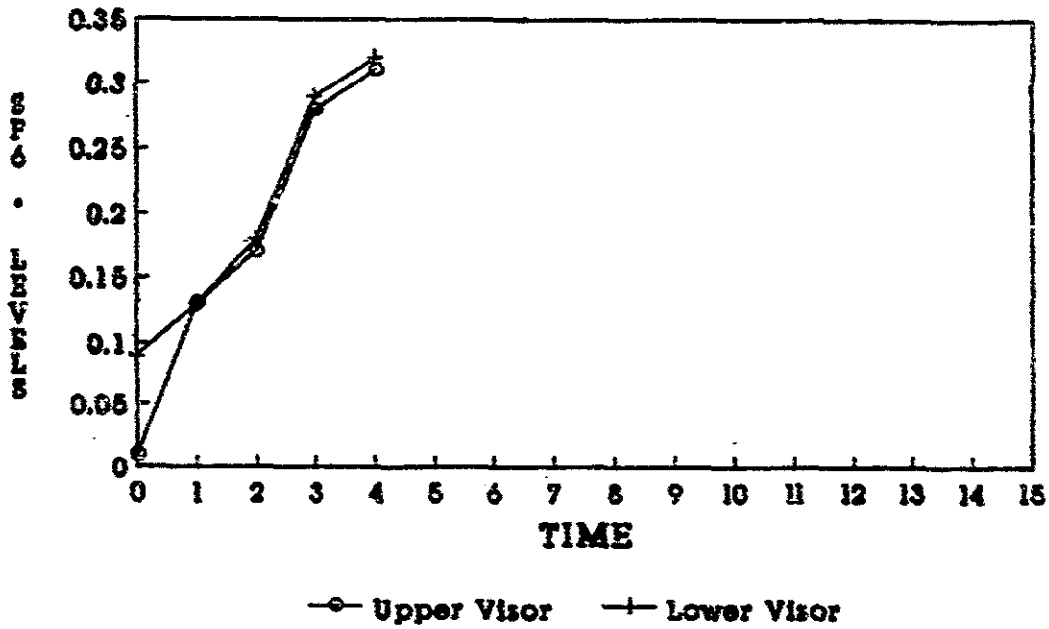
CONTAMINANT LEAKAGE
SUBJECT F-8



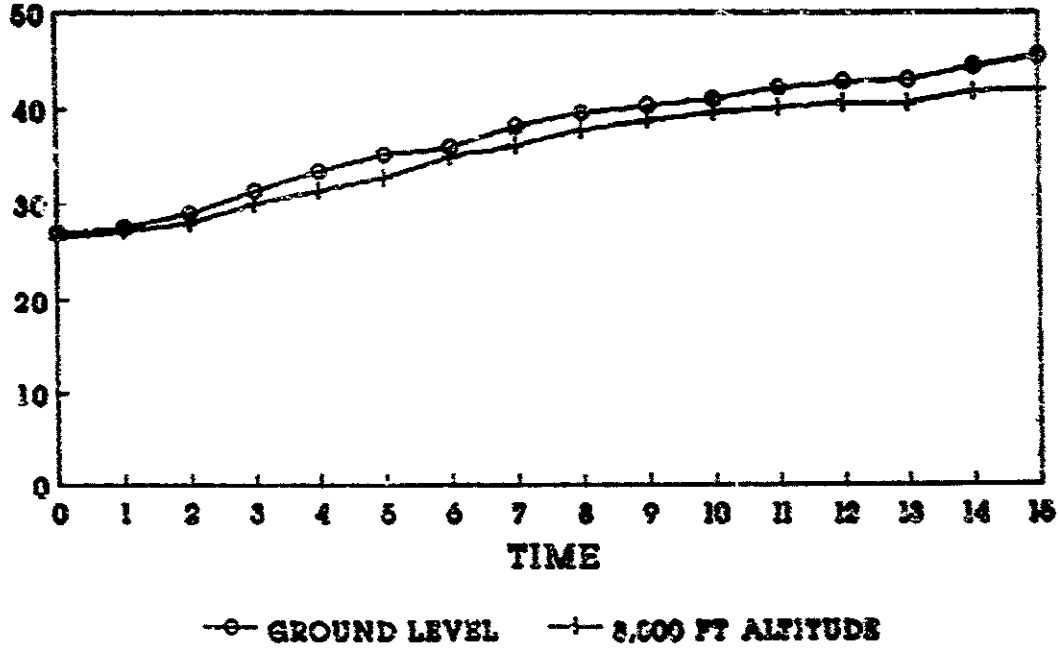
CONTAMINANT LEAKAGE
SUBJECT F-9



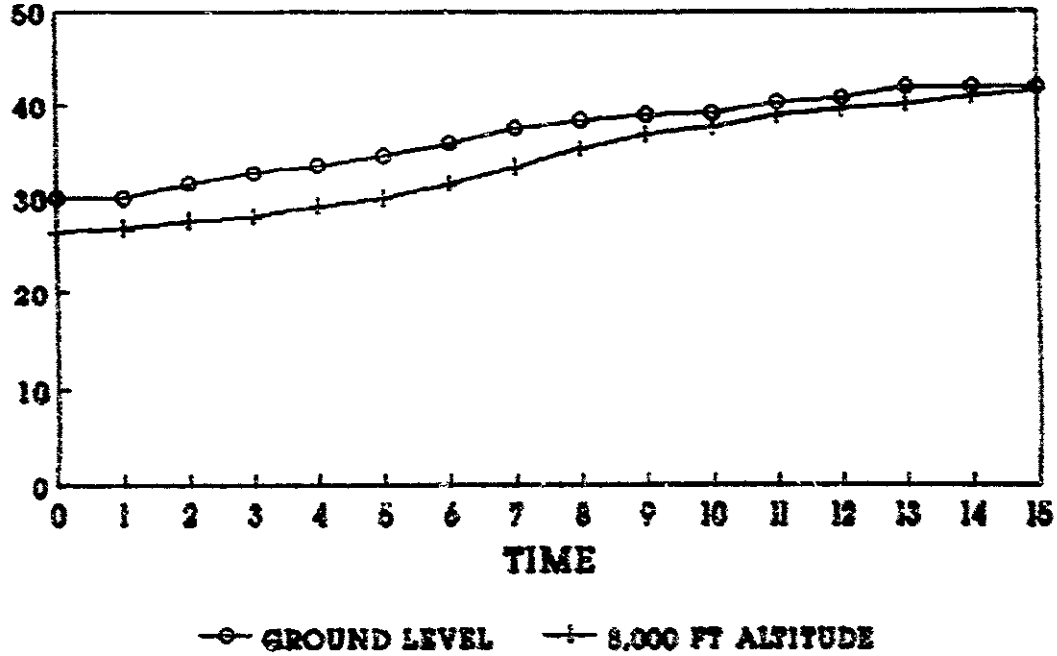
CONTAMINANT LEAKAGE
SUBJECT F-10



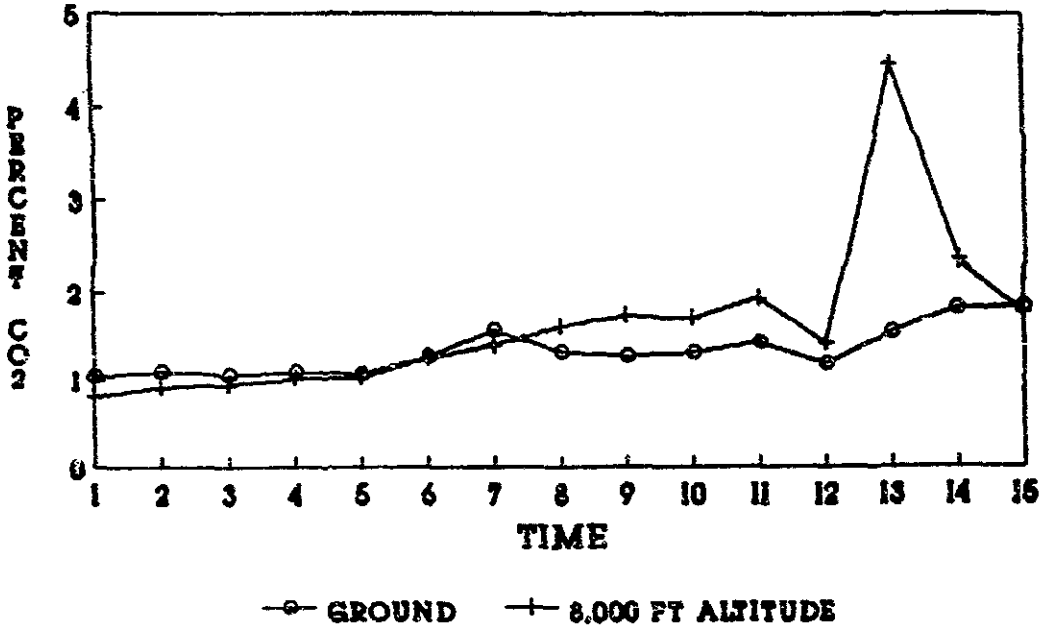
INTERNAL CPBE TEMPERATURE
SUBJECT M-8



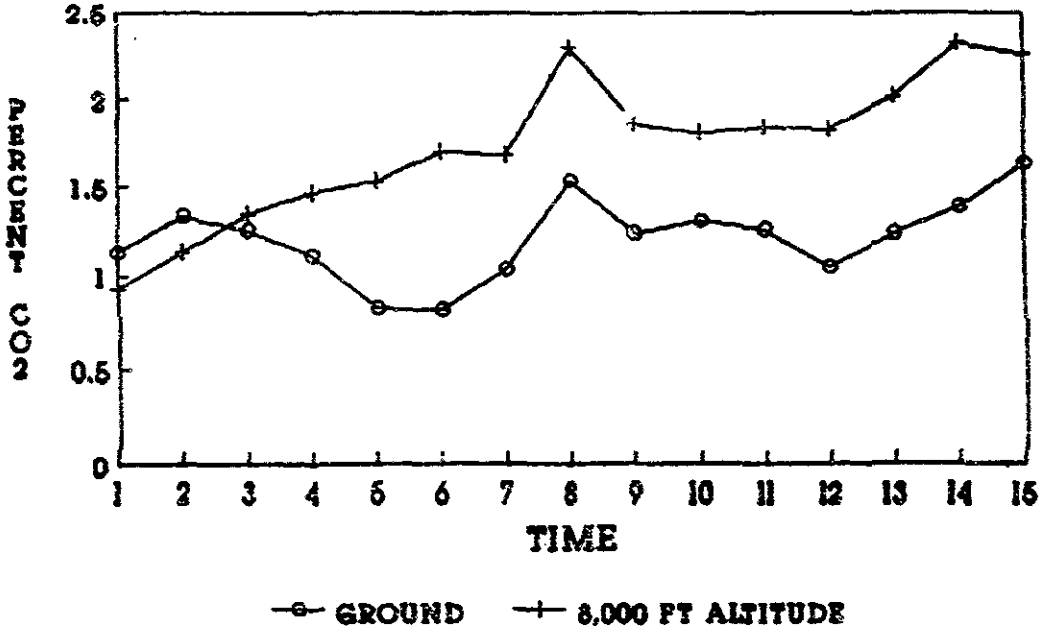
INTERNAL CPBE TEMPERATURE
SUBJECT M-11



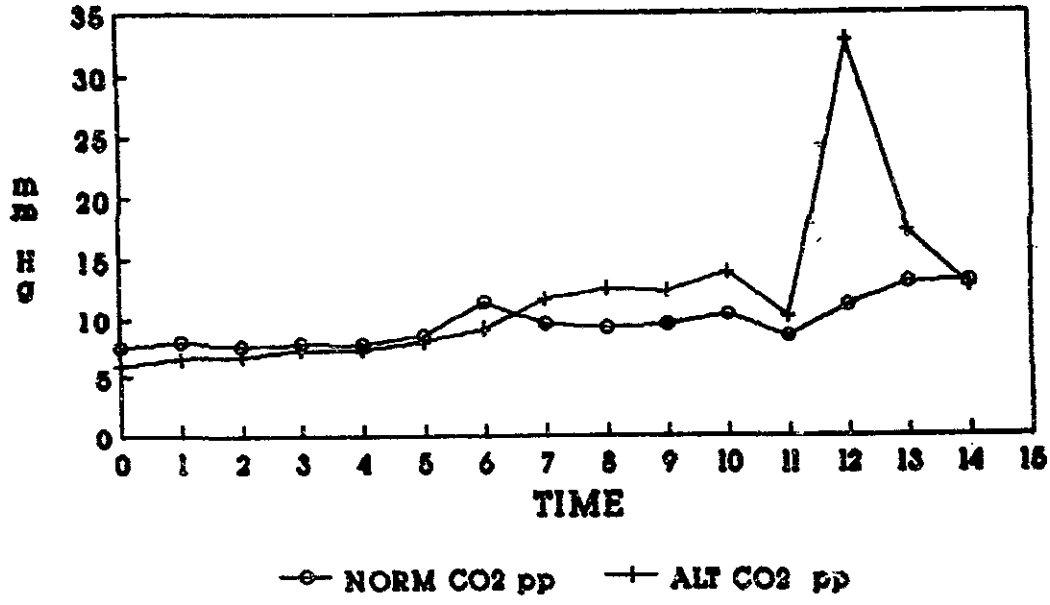
CARBON DIOXIDE LEVEL
SUBJECT M-3



CARBON DIOXIDE LEVEL
SUBJECT M-11

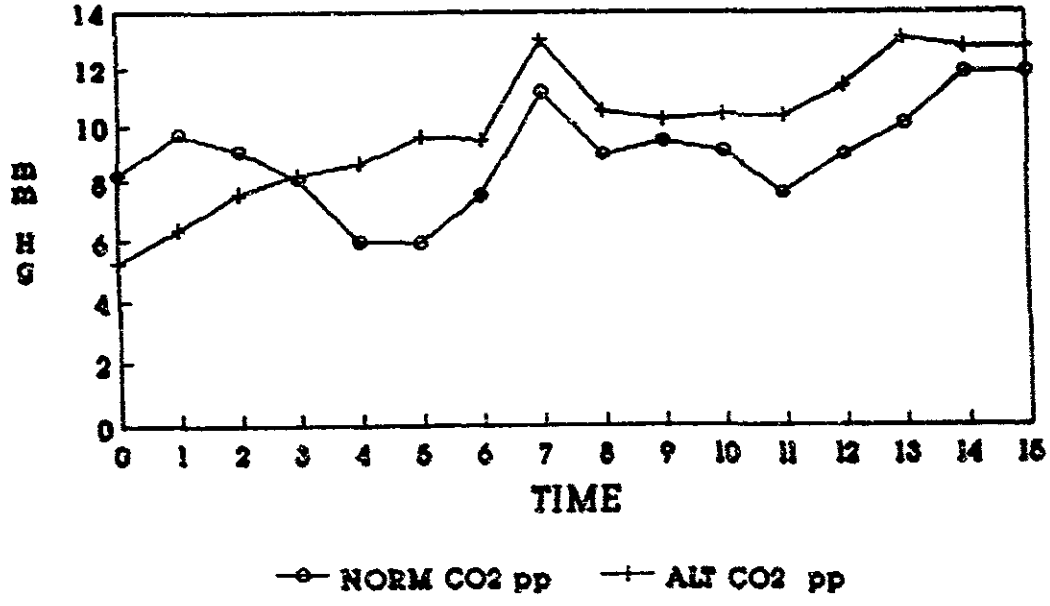


CARBON DIOXIDE LEVEL
SUBJECT M-3



4% sea level=30.4mm Hg
5% sea level=38.4mm Hg

CARBON DIOXIDE LEVEL
SUBJECT m-11

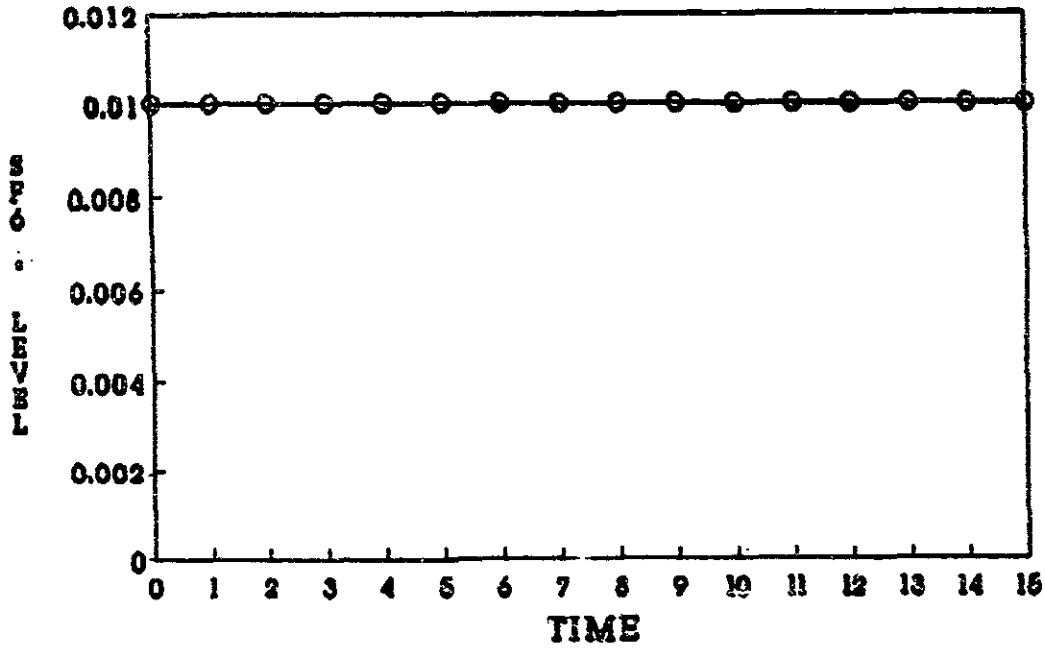


4% sea level=30.4mm Hg
5% sea level=38.4mm Hg

APPENDIX B

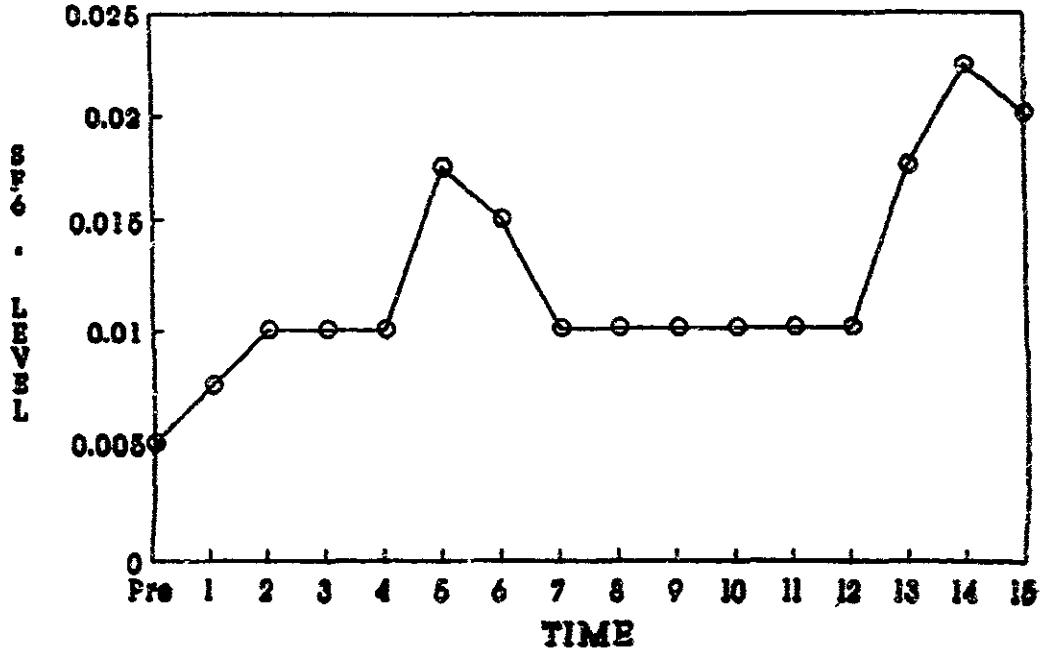
SF6 levels are presented as the concentration within the hoods. To determine the percentage of the 1% chamber concentration, multiply the concentration by 100.

CONTAMINANT LEAKAGE
SUBJECT M-1



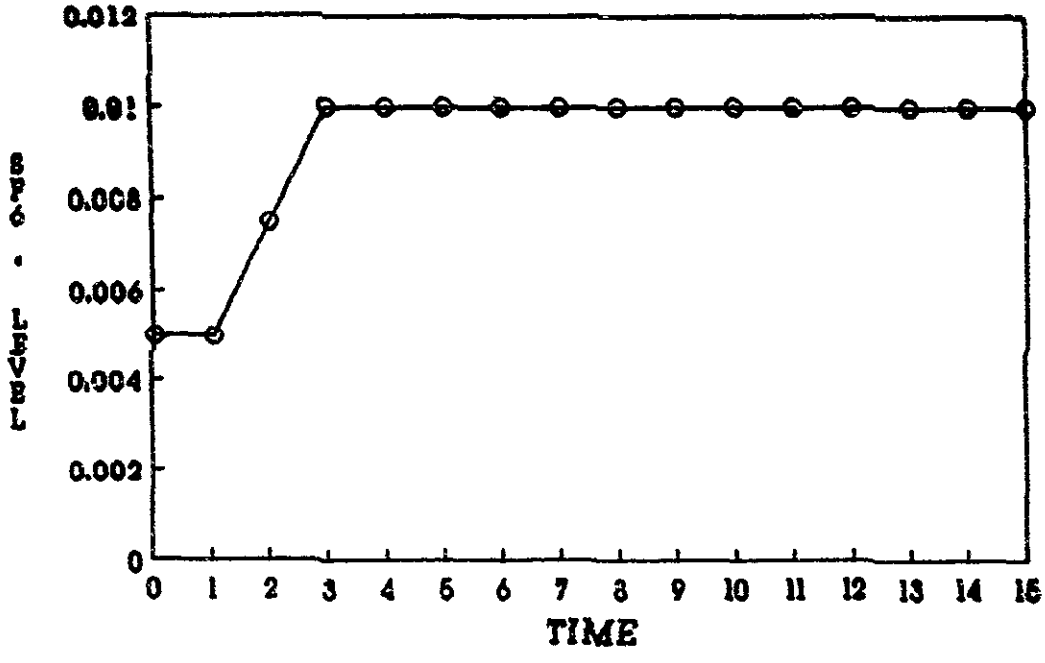
2.75 INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT F-1



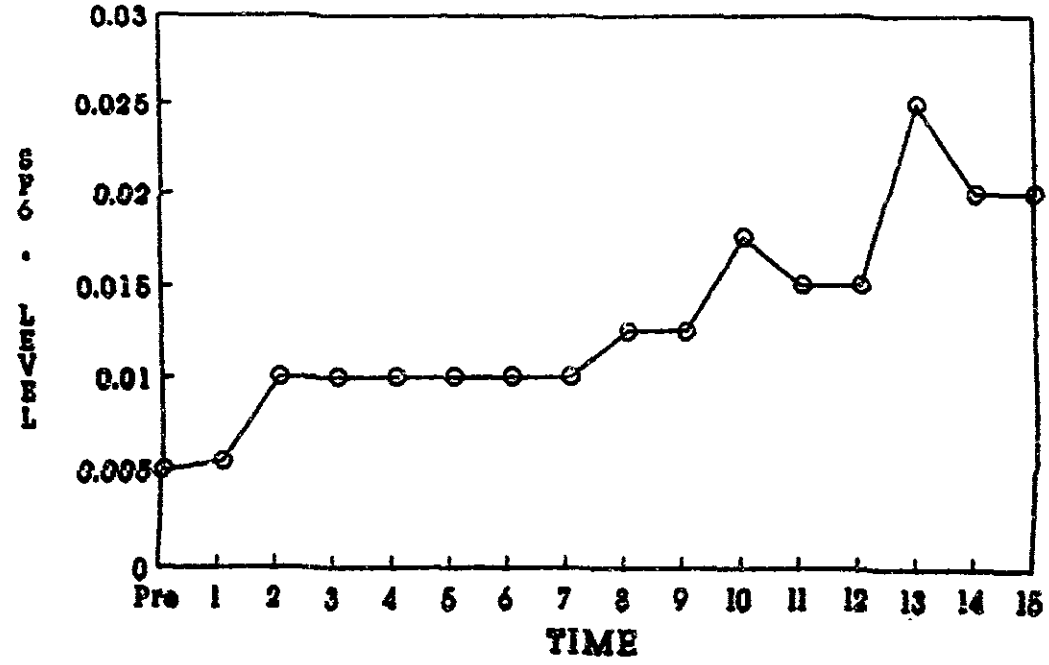
2.75 INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT F-3



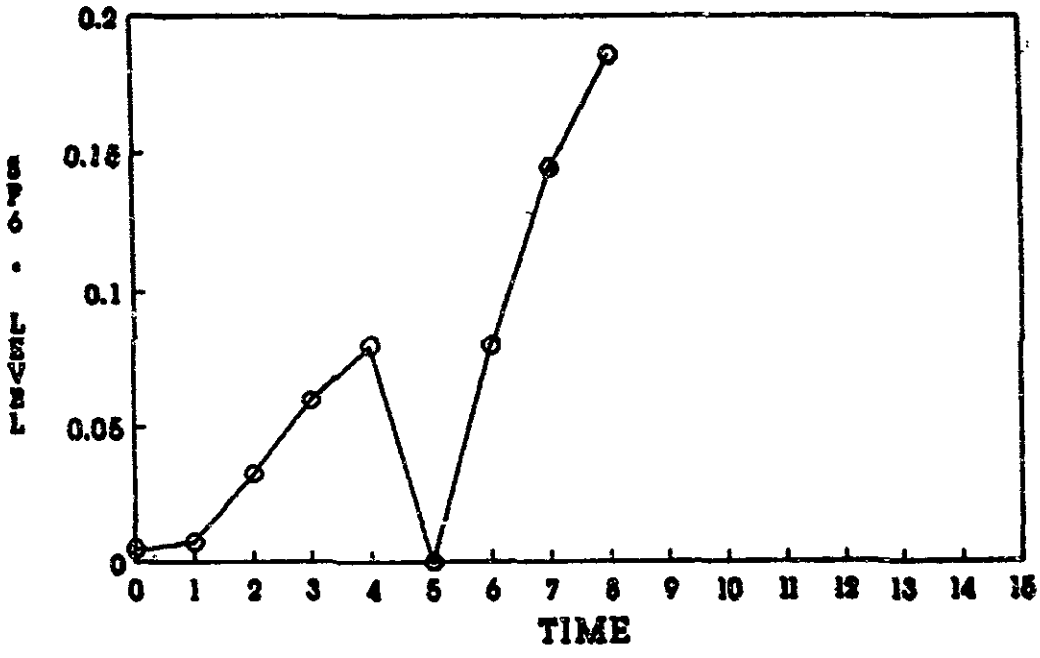
2.75 INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT F-5



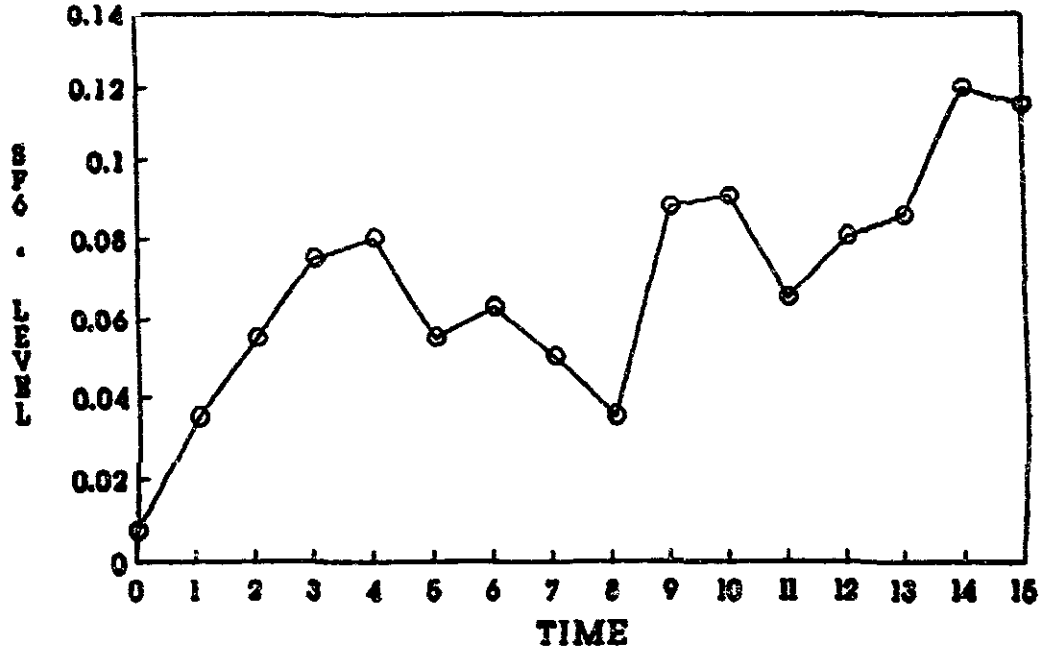
2.75 INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT M-2



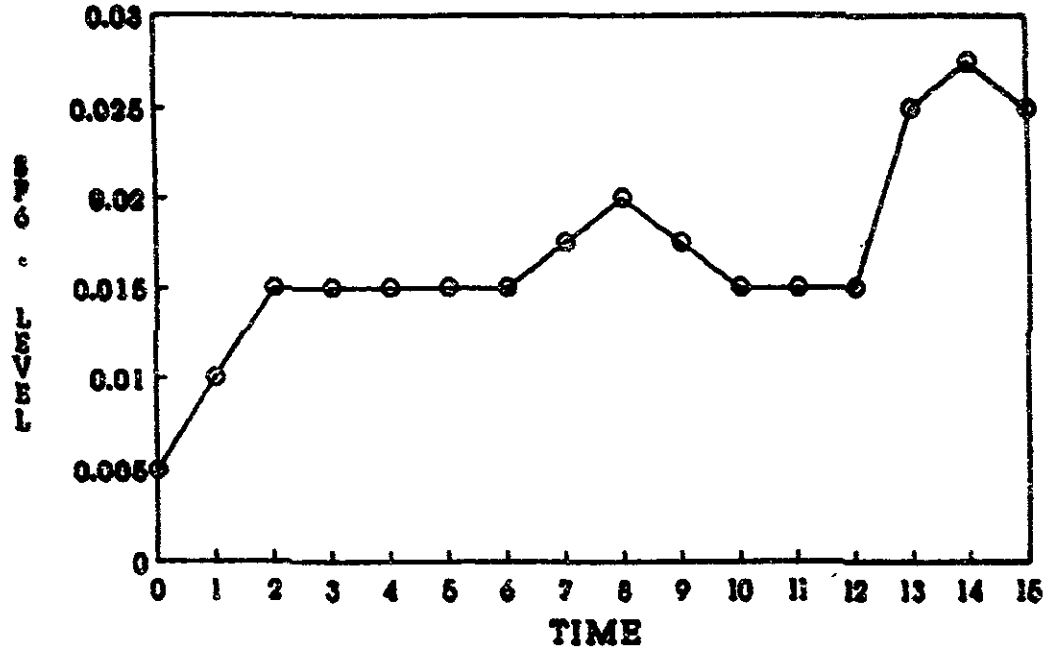
2.75 INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT F-4



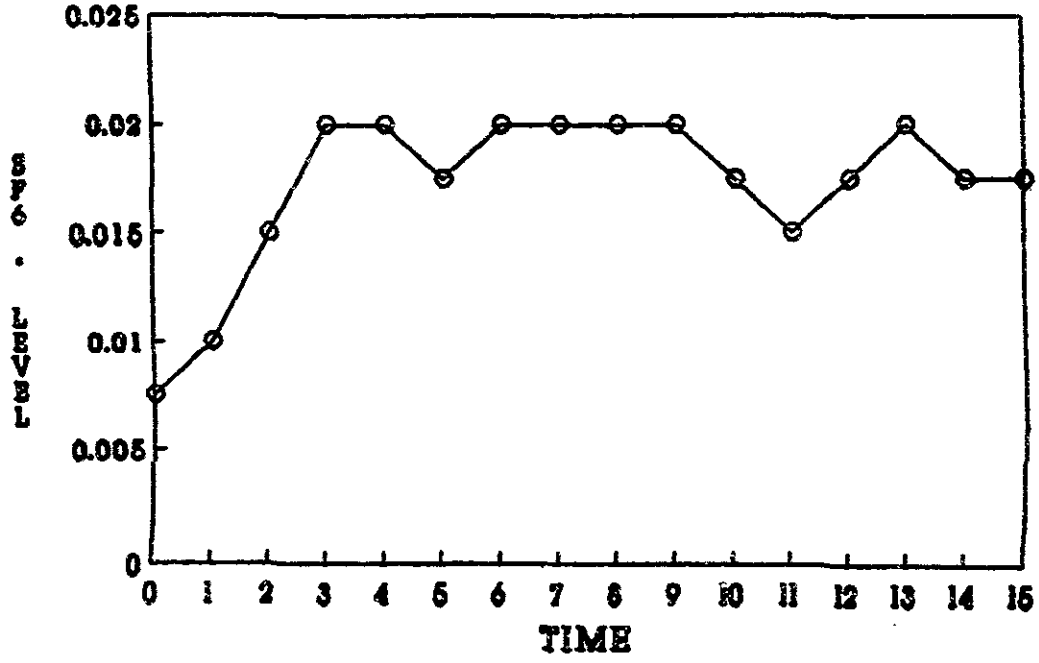
2.75 INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT M-2



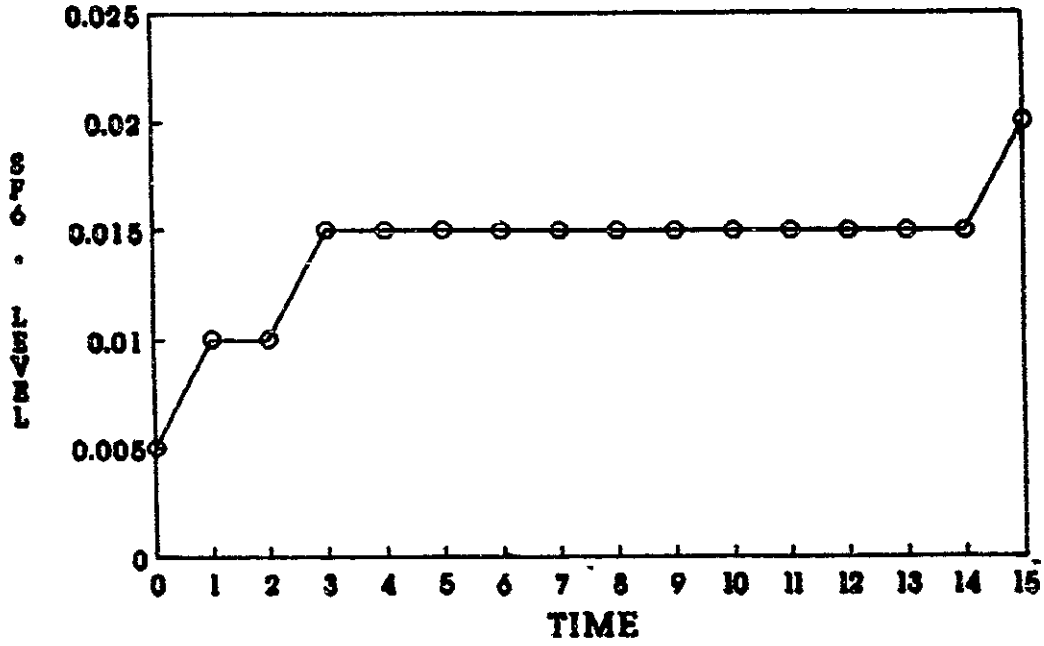
2.5-INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT F-4



2.5 INCH NECK SEAL

CONTAMINANT LEAKAGE
SUBJECT M-3



2.5 INCH NECK SEAL

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