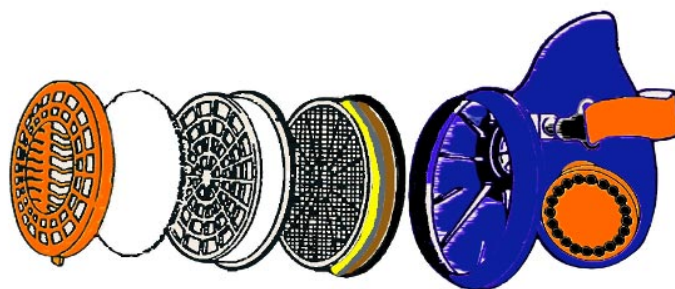




Repeated Inward Leakage tests



September 1997
Safety Equipment Australia Pty Ltd

Abstract

For many years SEA has conducted Fit Test Programs at different workplaces in Australia. One of the places that has been visited several times is Boyne Smelters Ltd in Gladstone. Some people have been tested more than one time during these tests. For most of these repeated tests either the mask or the features of the subject have changed. A few of the subjects were tested with the same mask and with the same features though.

At the last Fit Test Program at Boyne Smelters Ltd, conducted in April 1997, we also made repeated tests for some subjects. The tests were made at different days. No subject was tested more than once each day during the test period. The subjects were tested 2 - 4 times each.

All tests were done with the Sundström SR 90 silicone half mask, in a constant concentration of paraffin oil aerosol.

The results from these tests are presented in this paper.

Repeated Inward Leakage Tests

During the years SEA has conducted several Fit Test Programs at the Boyne Smelters Ltd in Gladstone. Some people have been tested more than one time during these tests. For most of these repeated tests either the mask or the features of the subject have changed. A few of the subjects were tested with the same mask and with the same features though.

These test results are presented below.

At the last Fit Test Program at Boyne Smelters Ltd, conducted in April 1997, we also made repeated tests for some subjects. The tests were made at different days. No subject was tested more than once each day during the test period. The subjects were tested 2 - 4 times each.

All tests below are done with the SR 90 half mask in silicone.

The test equipment

All tests were done in the same test equipment. It consists of the following parts.

Test chamber (SEA).

Austredex 785 MKII variable speed treadmill.

Aerosol generator (TSI 3076).

Photometer (Air Techniques TDA-2E).

Chart recorder (Seconic SS-250F).

IBM compatible computer.

Air compressor.

Sundström SR69/9 Compressed Air Filter.

Paraffin oil is used as test media and the particle size is mainly in the range of 0.1 μm to 1 μm . The average size is around 0.3 μm .

Test Procedure

Subjects are called in small groups from their work for the fit test. They are given a questionnaire form and are asked to supply the following information:

Demographic	Employment	Respirator
Name	Job Title	Currently Used Mask Model and Size **
Date of Birth	Job Description	Hours Used/Day
Sex	Shift/Crew	
Hours Since Last Shave *	Mutual Recognition	
	Unit	
Smoker	Supervisor Name	
Hours Since Last Smoke *		

* - New data fields for which statistics are not currently available.

** - The subject's mask is normally the test mask, but not always. The mask tested is recorded by the assisting staff (see below).

Bold type - Statistically analyzed.

The questionnaire also summarizes the test procedure so the subject understands what is required when in the test chamber.

When the questionnaire is completed, the following information is recorded by the attending hygienist or SEA representative.

Physiognomy	Respirator
Bizygomatic Diameter	Test Mask Condition *
Menton-Nasal Root Depression Length	Fitting Instruction Required *
Mouth Width	
Facial Features	
Race	

* - New data fields for which statistics are not currently available.

Bold type - Statistically analyzed.

If the respirator is found to be in poor condition, normally it is not repaired prior to testing, to see if the problem has placed the subject at risk. If the respirator is incorrectly fitted, then normally training is given prior to the test. The procedure for when a mask is found in poor condition or is incorrectly fitted is at the hygienists discretion, and determined prior to the fit test program commencement.

A high efficiency particulate filter and test adapter are fitted to the respirator that allow an instrument probe to sample the air inside the respirator without compromising the respirator's seal or integrity.

The subject then enters the test chamber and attaches the instrument probe (a 6 mm ID clear tube) to the test adapter. The treadmill is then started and set to a brisk walking pace (approximately 6 km/h).

The particle detector is then calibrated to ensure accuracy should there be any drift in the chamber aerosol concentration between tests, and the readings are taken. These readings indicate the percentage leakage of aerosol into the respirator, and are plotted by a calibrated chart recorder.

While measurements are taken the subject is instructed to perform the following activities:

- A. Walking - Head still.
- B. Walking - Moving head from side to side.
- C. Walking - Moving head up and down.
- D. Walking - Loudly speaking the alphabet.
- E. Walking - Head still.

These activities are performed for around one minute each to determine if the respirator seal may be compromised when such tasks are performed in the workplace.

Where unexplained leakage is recorded the subject is asked to leave the chamber and is inspected by attending staff to determine the reason. If the cause of the leakage can be corrected immediately the subject is then retested. If a subject needs to shave to achieve an acceptable fit factor, he is instructed to do so and return prior to the fit test program completion.

When all testing for the subject is concluded, the sample adapter is removed from the test mask and the following information (determined by the examiner) is recorded in the database.

Facial Fit Test	Other
Test Date	Temperature
Respirator Model Tested	Subject Comments
Edge (if applicable)***	Examiner Advice
Activity Leakage (A,B,C,D,E)	
Mean Leakage ((A+B+C+D+E)/5)	
Mean Fit Factor (100/((A+B+C+D+E)/5))	
Test Result (Pass/Fail)	

Bold type - Statistically analyzed.

*** - The filter leakage is called "edge value" and is subtracted from the total leakage value in order to get the facepiece leakage. If a P3 filter is used no edge value is entered.

Results

Subject 1244 was tested the first time in august 1988 and was tested again in April 1997. It is a clean shaven male, born 1950.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
1719	1244	SR90	8/21/88	0.06	0.05	0.05	0.05	0.045	0.051	1961
4613	1244	SR90	4/14/97	0.01	0.01	0.01	0.01	0.01	0.01	10000
AVERAGE				0.035	0.03	0.03	0.03	0.0275	0.0305	
STDEV				0.035	0.028	0.028	0.028	0.025	0.029	
COE. OF VAR.				1.010	0.943	0.943	0.943	0.900	0.951	
PF				2857	3333	3333	3333	3636	3279	
+STDEV				1421	1716	1716	1716	1914	1681	
+2 STDEV				946	1155	1155	1155	1299	1130	

Table 1.

Subject 2530 was tested several times the same day in June 1993 and was tested again in April 1997. It is a clean shaven male, born 1963.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4030	2530	SR90	6/29/93	0.04	0.07	0.07	0.15	0.06	0.078	1282
4031	2530	SR90	6/29/93	0.1	0.07	0.1	0.06	0.06	0.078	1282
4033	2530	SR90	6/29/93	0.21	0.21	0.22	0.3	0.22	0.232	431
4611	2530	SR90	4/14/97	0.15	0.08	0.04	0.03	0.02	0.064	1562
AVERAGE				0.125	0.1075	0.1075	0.135	0.09	0.113	
STDEV				0.072	0.068	0.079	0.121	0.089	0.080	
COE. OF VAR.				0.579	0.637	0.734	0.898	0.985	0.704	
PF				800	930	930	741	1111	885	
+STDEV				507	568	536	390	560	519	
+2 STDEV				371	409	377	265	374	367	

Table 2.

Subject 2686 was tested in July 1993 and was tested again in April 1997. It is a male with mustache, born 1965.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4209	2686	SR90	7/2/93	0.8	0.8	0.8	1.4	0.4	0.84	119
4756	2686	SR90	4/16/97	0.012	0.013	0.013	0.013	0.012	0.0126	7936
AVERAGE				0.406	0.4065	0.4065	0.7065	0.206	0.4263	
STDEV				0.557	0.556	0.556	0.981	0.274	0.585	
COE. OF VAR.				1.372	1.369	1.369	1.388	1.332	1.372	
PF				246	246	246	142	485	235	
+STDEV				104	104	104	59	208	99	
+2 STDEV				66	66	66	37	133	63	

Table 3.

Subject 3070 was tested the 14 and 16 of April 1997. It is a clean shaven male, born 1976.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4649	3070	SR90	4/14/97	0.013	0.013	0.013	0.01	0.01	0.0118	8474
4717	3070	SR90	4/16/97	0.012	0.01	0.01	0.01	0.01	0.0104	9615
AVERAGE				0.0125	0.0115	0.0115	0.01	0.01	0.0111	
STDEV				0.001	0.002	0.002	0.000	0.000	0.001	
COE. OF VAR.				0.057	0.184	0.184	0.000	0.000	0.089	
PF				8000	8696	8696	10000	10000	9009	
+STDEV				7572	7341	7341	10000	10000	8271	
+2 STDEV				7187	6352	6352	10000	10000	7645	

Table 4.

Subject 3071 was tested the 14, 16 and 17 of April 1997. It is a clean shaven male, born 1970.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4650	3071	SR90	4/14/97	0.1	0.06	0.06	0.03	0.03	0.056	1785
4718	3071	SR90	4/16/97	0.026	0.025	0.028	0.013	0.01	0.0204	4901
4753	3071	SR90	4/17/97	0.09	0.09	0.08	0.05	0.06	0.074	1351
AVERAGE				0.072	0.058	0.056	0.031	0.033	0.050	
STDEV				0.040	0.033	0.026	0.019	0.025	0.027	
COE. OF VAR.				0.558	0.558	0.468	0.597	0.755	0.544	
PF				1389	1714	1786	3226	3000	1995	
+STDEV				892	1101	1216	2019	1709	1292	
+2 STDEV				657	810	922	1470	1195	955	

Table 5.

Subject 3072 was tested 14, 16, 17 and 18 of April 1997. It is a female, born 1965.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4651	3072	SR90	4/14/97	0.1	0.1	0.03	0.03	0.02	0.056	1785
4721	3072	SR90	4/16/97	0.01	0.01	0.01	0.01	0.01	0.01	10000
4762	3072	SR90	4/17/97	0.013	0.017	0.01	0.01	0.011	0.0122	8196
4763	3072	SR90	4/18/97	0.018	0.012	0.01	0.01	0.01	0.012	8333
AVERAGE				0.035	0.035	0.015	0.015	0.013	0.023	
STDEV				0.043	0.044	0.010	0.010	0.005	0.022	
COE. OF VAR.				1.228	1.255	0.667	0.667	0.381	0.990	
PF				2837	2878	6667	6667	7843	4435	
+STDEV				1273	1276	4000	4000	5680	2229	
+2 STDEV				821	820	2857	2857	4452	1488	

Table 6.

Subject 3073 was tested 14, 16, 17 and 18 of April 1997. It is a female, born 1954.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4652	3073	SR90	4/14/97	0.01	0.01	0.01	0.013	0.03	0.0146	6849
4720	3073	SR90	4/16/97	0.02	0.025	0.025	0.022	0.018	0.022	4545
4764	3073	SR90	4/17/97	0.01	0.01	0.014	0.013	0.01	0.0114	8771
4765	3073	SR90	4/18/97	0.01	0.011	0.01	0.01	0.01	0.0102	9803
AVERAGE				0.013	0.014	0.015	0.015	0.017	0.015	
STDEV				0.005	0.007	0.007	0.005	0.009	0.005	
COE. OF VAR.				0.400	0.525	0.481	0.358	0.556	0.364	
PF				8000	7143	6780	6897	5882	6873	
+STDEV				5714	4684	4579	5077	3780	5037	
+2 STDEV				4444	3485	3457	4017	2785	3975	

Table 7.

Subject 3074 was tested 14, 16, 17 and 18 of April 1997. It is a male with mustache, born 1942.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4653	3074	SR90	4/14/97	0.01	0.01	0.02	0.012	0.012	0.0128	7812
4766	3074	SR90	4/16/97	0.01	0.01	0.01	0.01	0.01	0.01	10000
4767	3074	SR90	4/17/97	0.025	0.02	0.015	0.011	0.015	0.0172	5813
4768	3074	SR90	4/18/97	0.01	0.01	0.01	0.01	0.01	0.01	10000
AVERAGE				0.014	0.013	0.014	0.011	0.012	0.013	
STDEV				0.008	0.005	0.005	0.001	0.002	0.003	
COE. OF VAR.				0.545	0.400	0.348	0.089	0.201	0.272	
PF				7273	8000	7273	9302	8511	8000	
+STDEV				4706	5714	5395	8542	7086	6289	
+2 STDEV				3478	4444	4287	7896	6070	5181	

Table 8.

Subject 3149 was tested 13, 16, 17 and 18 of April 1997. It is a clean shaven male, born 1954.

Ref. no.	Sub.	Mask	Date	A	B	C	D	E	Aver.	PF
4757	3149	SR90	4/13/97	0.025	0.025	0.025	0.015	0.025	0.023	4347
4759	3149	SR90	4/16/97	0.01	0.01	0.01	0.07	0.01	0.022	4545
4760	3149	SR90	4/17/97	0.01	0.01	0.01	0.01	0.01	0.01	10000
4761	3149	SR90	4/18/97	0.01	0.01	0.01	0.11	0.01	0.03	3333
AVERAGE				0.014	0.014	0.014	0.051	0.014	0.021	
STDEV				0.008	0.008	0.008	0.048	0.008	0.008	
COE. OF VAR.				0.545	0.545	0.545	0.930	0.545	0.391	
PF				7273	7273	7273	1951	7273	4706	
+STDEV				4706	4706	4706	1011	4706	3384	
+2 STDEV				3478	3478	3478	682	3478	2642	

Table 9.

Conclusions

As always when dealing with inward leakage figures the first conclusion is that we should need more test data. Calculating average values and standard deviations for two test results is of course not recommended.

Though, even if there is a limited amount of test results, one can see a pattern. There is only one test subject that is getting both a very good and a poor test result. This test subject has a mustache and was tested 1993 and 1997. It should have been very interesting to know how the mustache looked four years ago. All the other test subjects are staying on a good protection level all the time. The coefficient of variation¹ is high for most of the subjects but even if we add one or two standard deviations to their average leakage they will still stay on a good protection level.

The message to the users of this type of breathing protection equipment is clear.

- **Stay with the features you are tested with,**
- **Maintain your mask,**
- **Wear it all the time you should,**
- **Change filter regularly**

and you are getting a good protection!

We also think that these results highlights the value of running a Breathing Protection Program which together with the users attitude to their RPE very much influences the level of protection achieved.

It will be very exciting to see if this trend will be continued when we expand these repeated tests which we intend to do.

Safety Equipment Australia Pty Ltd.

Lennart Bäckman

September 1997

1. The coefficient of variation is the ratio between the standard deviation and the average value.