WEAR TIME AND PEAK AIRFLOW MONITORING IN A LEAD SMELTER

Sanya Kranenburg, BE Mech (Hons)
Product Manager
Safety Equipment Australia Pty Ltd
Private Bag 1001
Mona Vale NSW 2103
AUSTRALIA
Tel.: +61 (0)2 9910 7500
Fax: +61 (0)2 9979 5364
Email: sanya.kranenburg@seasafe.com.au

September 2002

Purpose

The purpose of this project was to prepare a report on an occupational health and safety problem in a lead smelter. Our company was invited to assist in solving the issues the smelter had with the employees' high lead levels in the blood. The employees were tested every four or six weeks depending on the number of hours they were working.

Once an employee reaches a certain "transfer level", he or she has to be removed from the high-lead area to lower-lead areas. In the event that an employee's lead blood level has reached this "transfer level", the most common practice is that a subcontractor is called in to carry out the work. This, of course, contributes to high labour costs.

Another most important consideration is that lead is a very dangerous contaminant and is well known to have very serious health effects. It is believed that long-term exposure can contribute to Alzheimer's decease, early aging etc.

We can further find in the SEA SE-Data chemical database that lead can contribute to headache, nausea, loss of appetite, and other complaints.

The Occupational Exposure Limits (OELs) currently in use in Australia are the *Exposure Standards for Atmospheric Contaminants in the Occupational Environment,* published by the National Occupational Health & Safety Commission (NOHSC).

Exposure Standards are lists of numbers that indicate maximum allowed concentrations of airborne hazardous substances. Previously the OELs used were the American Threshold Limit Values or TLVs, published by the American Conference of Governmental Industrial Hygienists (ACGIH). [ref 2]

Below I have listed the TLV levels for lead. As you can see they vary between countries:

- Australia 0.15mg/m3 (inorg).
- Germany 0.1mg/m3
- Sweden 0.05 mg/m3

- US—NIOSH 0.1mg/m3
- US—OSHA 0.05mg/m3.

We can also see that these TLV levels can even vary within a country between different organizations.

To better understand the reasons for the variations, I compared these values in our chemical database with the ACGIH publications:

Lead, elemental CAS7439-92-1 and inorganic compounds as Pb (1995) TWA (Time Weighted Average limit level) was listed as 0.05mg/m3 in the ACGIH publication. [ref 2]

Then comparing this value with the corresponding booklet from1998, the values were exactly the same. [ref 3]

Workplace Background:

The lead smelter has a capacity of 250,000 tonnes of refined lead, 40,000 tonnes of zinc and 450,000 kg of silver per annum. The smelter employs roughly 600 employees and contractors.

The lead smelter is a very old one, and to change the engineering and processing aspects of the smelter would entail enormous costs. However, leaks and other maintenance issues are attended to immediately when identified.

Unfortunately, the sheer size of the smelter, costs, engineering, and available technology are limiting the possibility of "eliminating the hazard from the machine, guarding or otherwise minimizing the hazard at its source". Because of this, management has no other choice than safeguarding the operator through the use of personal protective equipment. [ref 4]

The lead smelter conducts regular dust monitoring of all parts of the plant, as well as right through the local surroundings.

The dust levels can vary widely between 10 PPM to10,000 PPM, depending on where the dust testing is conducted. The dust monitoring part of the project was completely left up to the smelter, as very sophisticated and expensive equipment had been bought recently to carry out this type of work.

The project was carried out over a period of six months, during which period we monitored respiratory wear time and also performed airflow measurement testing.

Hazard Identification

Within a lead smelter process, the main contaminants are lead, zinc, silver, gold and sulphur dioxide. The level of contaminant and dust concentration levels vary between different parts of the plant.

The main routes of entry of lead are through inhalation and also at times through ingestion. Unfortunately, during our periodical visits we learnt that some employees would have chocolate bars in their pockets and eat while working in the plant. This can have big impact on the blood lead levels and can be very dangerous to health. As per our SE-Data chemical database, the first aid recommendation for swallowing lead is to take the person to the hospital immediately if any significant amounts have been ingested.

Inhalation seems to be the most common cause for lead in the blood. Currently, respirator wear is compulsory virtually throughout the site. The respirators are predominately half mask negative pressure respirators and PAPR (powered air purifying respirators).

One concern management of the lead smelter brought to our attention was that the wearers of PAPR tend to have major problems to keep their blood lead levels down. The common practice among the PAPR wearers is to switch over to negative pressure half masks as soon as the lead in their blood is too high. The negative pressure half mask has been able to bring down the blood lead to an acceptable level, that is, below the transfer level.

Lead can have even more serious effects on both women and men that want to have children.

Filter Selection

Our company has previously tested our filters, i.e. particle filters (P3) and gas filters (ABE – organic, inorganic and acid) in similar conditions.

The particle filter resistance was tested in accordance with *AS/NZS 1716:1994* [ref 5] to establish how long the filters would last in these conditions.

The gas filters were also tested to determine how long they would last typically in similar conditions to the ones at the lead smelter. The guidelines that were followed for the gas filters are as per Table 5.2 in abovementioned standard.

The process

22 employees were selected to participate in this project. Their lead levels varied between 11 and 40. The transfer level for the lead smelter is approximately 40.

Initially, we were inducted into the various parts of the smelter and issued with all the necessary safety garments to be worn on site: safety glasses, hard hat, thick cotton overalls and a half face negative pressure respirator. We wore our own safety boots.

Our staff also had to undergo a blood test for the management to check our blood lead levels. Most of us had lead levels between 1 and 2.

We started the project by conducting a 3–4 hour long training session about respiratory wear, filters, protection factors and also a bit about physiology. During this training, we trained the workers in the use and maintenance of our SE400 FPBR, Fan-supplied Positive Pressure Breath-responsive Respirator.

We also trained two people within the organisation in more in-dept maintenance of the equipment and the software side of the equipment, which involves downloading the wear information of the fan unit at regular intervals.

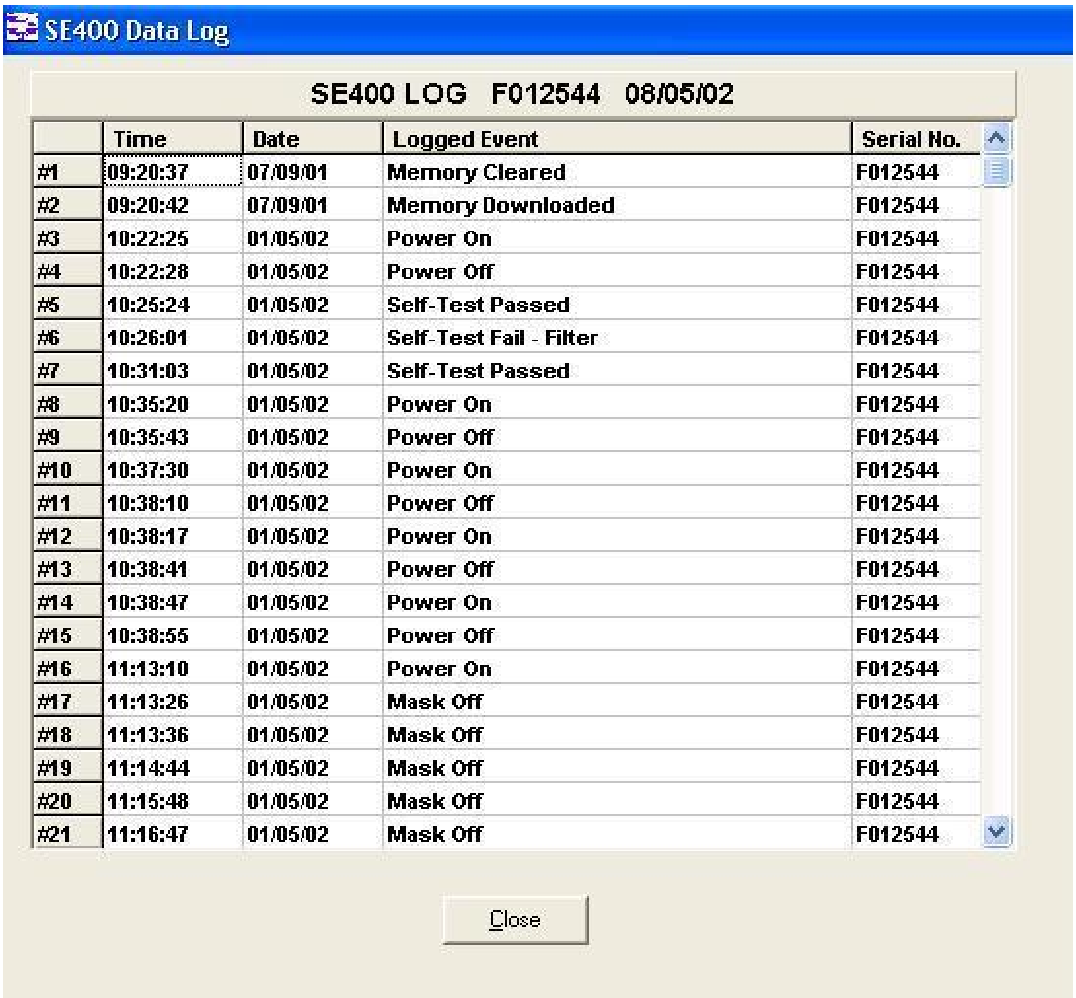
Data Logging

The data logging facility logs every event the unit and wearer has been up to. It logs every time the unit is turned on and off, every battery alarm, and every potential negative mask pressure

The information obtained from the regular downloading was later transferred to a summary file where we could monitor the SE400 user's respirator wearing pattern.

We asked the contact person on site to download the data initially every week. Later, we realised that every two weeks was often enough.

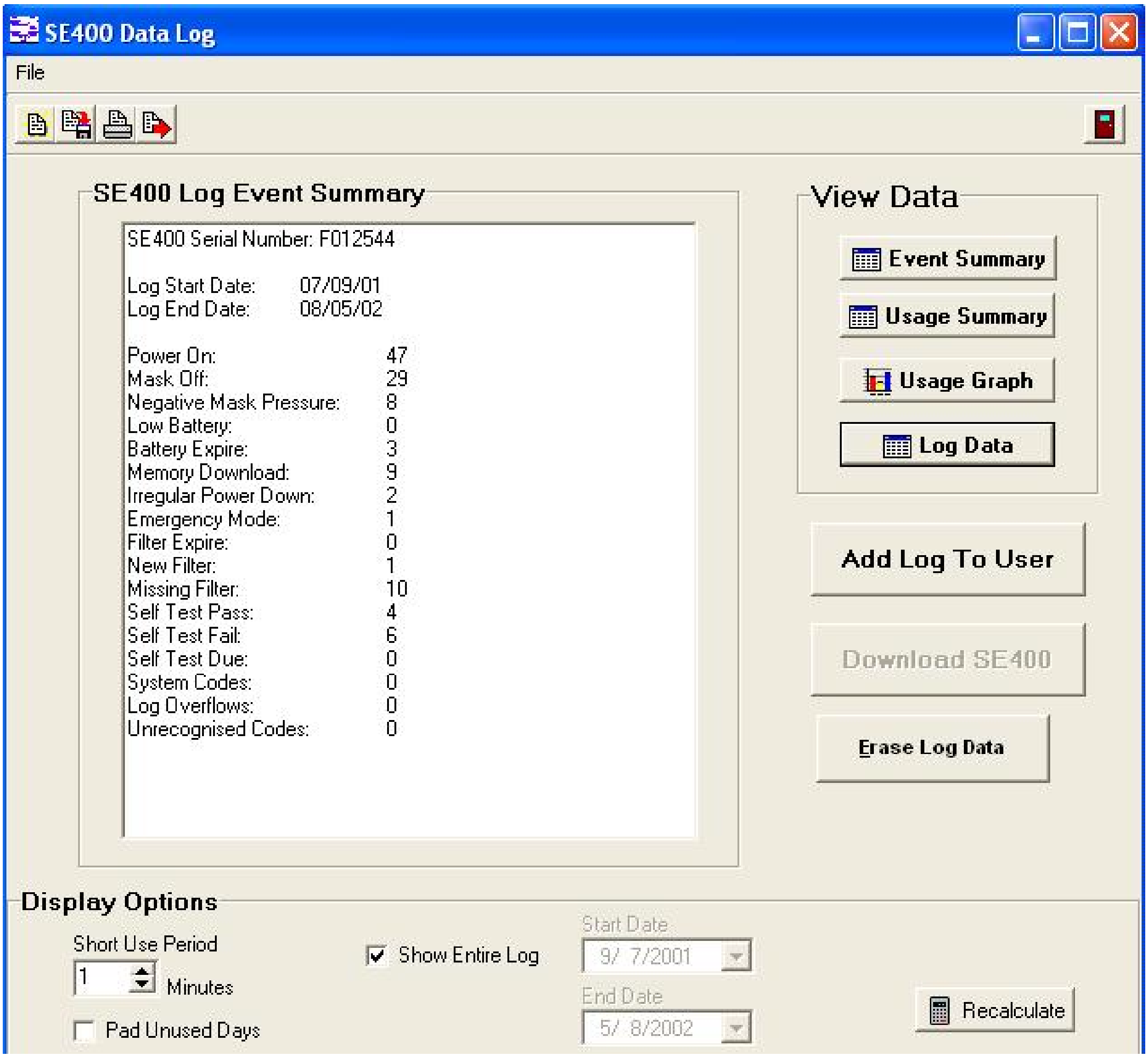
However, we soon found that the 500 rows of data logging was enough to last more than a month.



	Time	Date	Logged Event	Serial No.
#1	09:20:37	07/09/01	Memory Cleared	F012544
#2	09:20:42	07/09/01	Memory Downloaded	F012544
#3	10:22:25	01/05/02	Power On	F012544
#4	10:22:28	01/05/02	Power Off	F012544
#5	10:25:24	01/05/02	Self-Test Passed	F012544
#6	10:26:01	01/05/02	Self-Test Fail - Filter	F012544
#7	10:31:03	01/05/02	Self-Test Passed	F012544
#8	10:35:20	01/05/02	Power On	F012544
#9	10:35:43	01/05/02	Power Off	F012544
#10	10:37:30	01/05/02	Power On	F012544
#11	10:38:10	01/05/02	Power Off	F012544
#12	10:38:17	01/05/02	Power On	F012544
#13	10:38:41	01/05/02	Power Off	F012544
#14	10:38:47	01/05/02	Power On	F012544
#15	10:38:55	01/05/02	Power Off	F012544
#16	11:13:10	01/05/02	Power On	F012544
#17	11:13:26	01/05/02	Mask Off	F012544
#18	11:13:36	01/05/02	Mask Off	F012544
#19	11:14:44	01/05/02	Mask Off	F012544
#20	11:15:48	01/05/02	Mask Off	F012544
#21	11:16:47	01/05/02	Mask Off	F012544

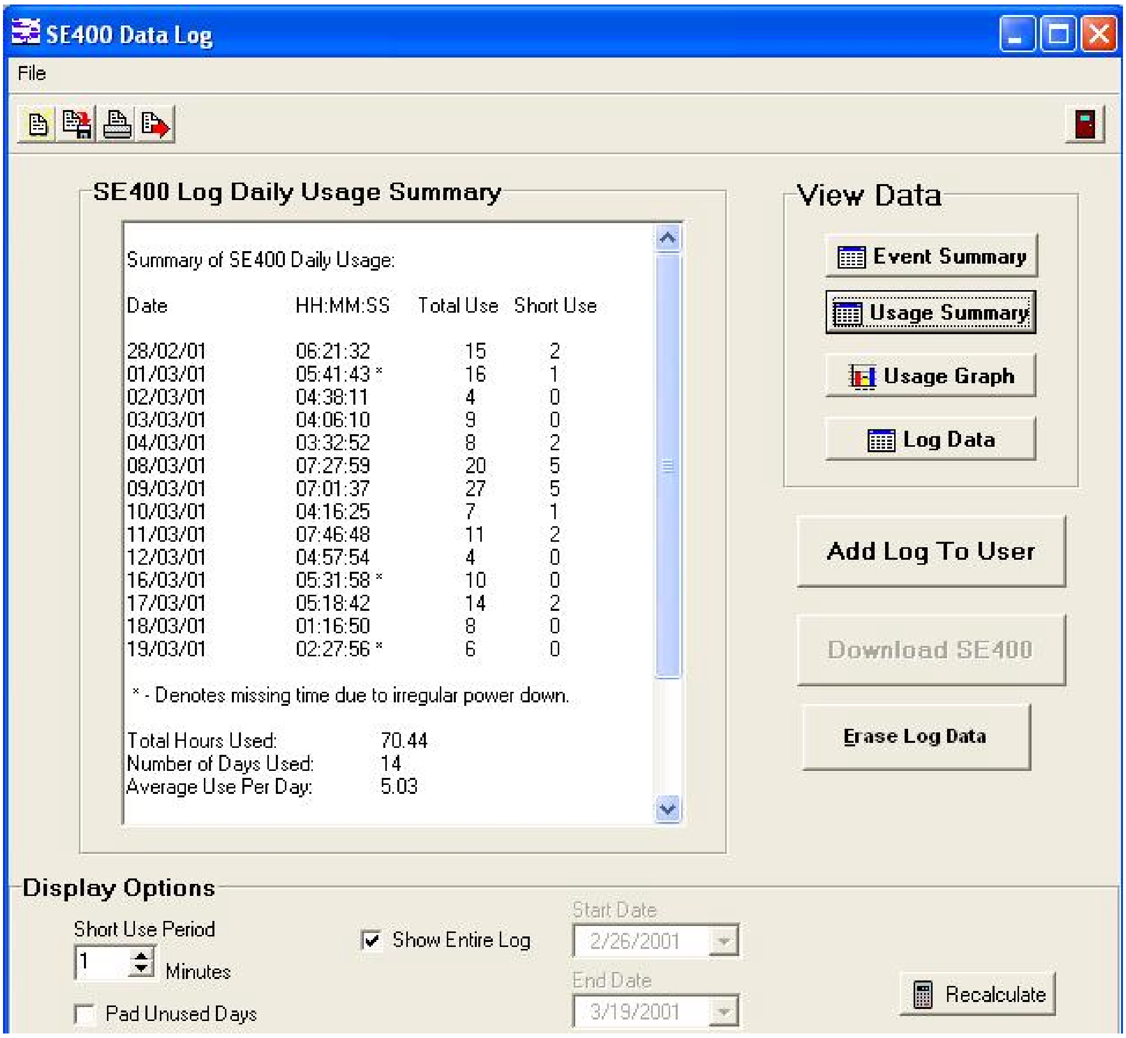
The Data Log (above) is the most detailed report available, showing us each event separately. We can tell exactly when something happened, when a battery or filter was changed, at which point the wearer momentarily ran into negative mask pressure, and so on.

Because the Data Log gives us individual information on every single event, it can be used to identify the exact nature and cause of any problem arising during the shift

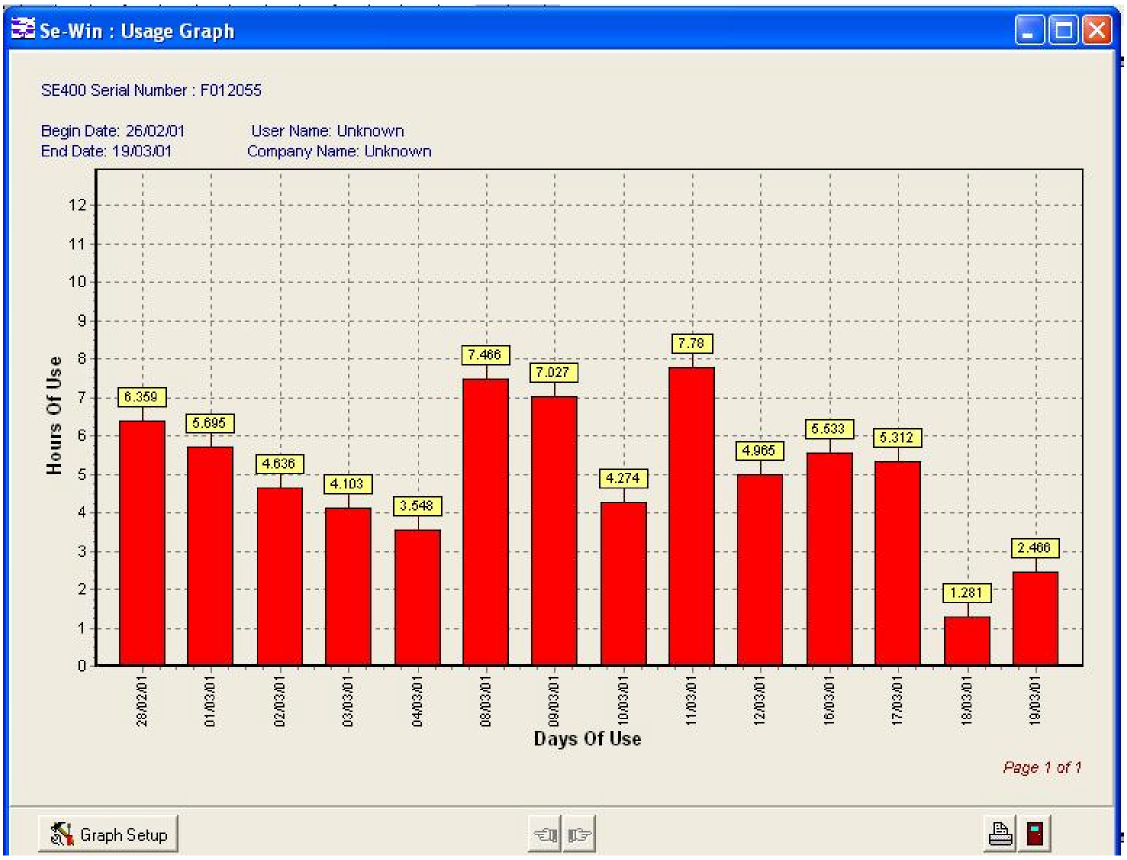


The unit also provides a summary of events (above).

This summary gives us a good overview of the events that have occurred during use, and can help us to identify any untoward occurrences. It tells us the *number of times* certain events have occurred, such as power-up, mask on, self test, negative pressure, battery change and so on.

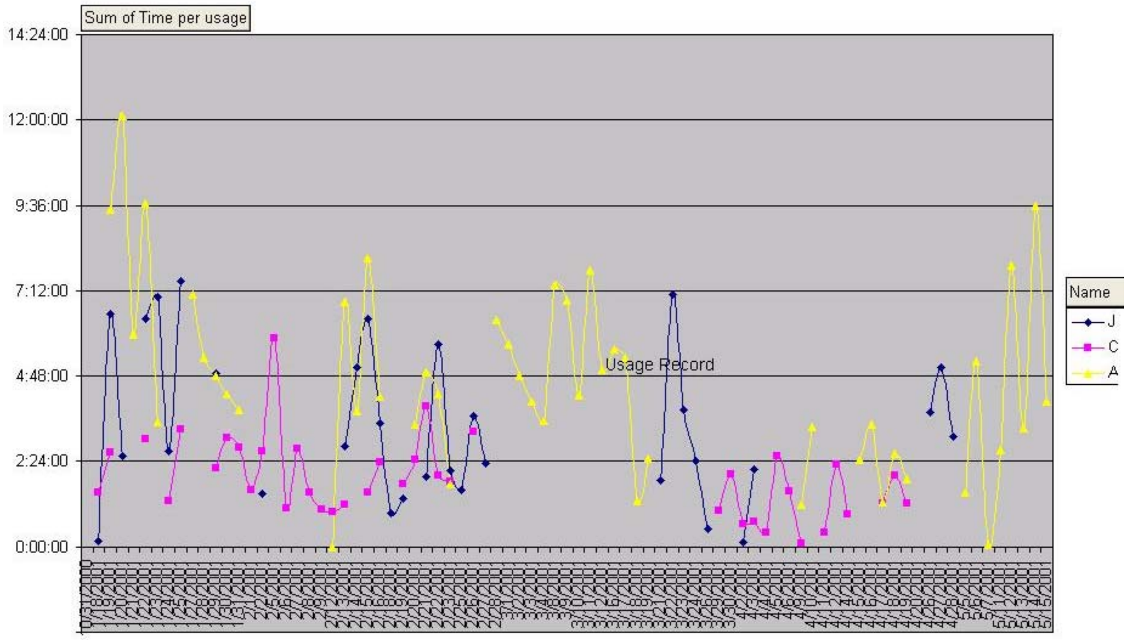


The Daily Usage Summary (above) tells us exactly how many hours and minutes the SE400 has been used each day. The SE-WIN software then looks at the "big picture" and shows us total usage over a longer period, and average use per day.



The Usage Graph (above) is a visual representation of usage over an extended period. Here we can easily discover trends and patterns in the use of the SE400 over time. This information can be exported into a spreadsheet file in which you can track several users and compare the SE400 respirator wear pattern of several users.

We created the summary graph below, in which we compared the patterns of various users. Here we have compared the wearing patterns of three out of the 22 SE400 users.



These wear patterns were later compared with the actual blood lead testing results that were conducted every 4-6 weeks.

One interesting finding was that it was **very apparent that the SE400 users that were using their units most had the most significant drops in blood lead levels. The highest measured drop was 6**. This lead reduction was generally in those that were wearing their respirator most of the time when they were in a contaminated area, that is, during 9–10 hours in a 12-hour shift, allowing for a few hours in the crib rooms.

Another matter of interest was that the wearers that were wearing their respirators only for minimum periods generally had very little or no lead reduction.

Issues brought to the management's knowledge

During this project, we received a fair amount of feedback from the lead smelter workers. We learnt that at certain times, variations in the blood lead counts depended on how the winds were blowing, that is, **in which direction exhaust air from the furnace was blowing**. One of the men had noticed that when he had stopped driving to work and had started to walk instead, his lead in blood had increased. He mentioned that he was aware of the dust in the area and that it sometimes was much worse than at other times. Because of this, we recommended to the management that personnel that were either walking or cycling to work should be allowed to bring a half mask negative pressure respirator with them home to put on when leaving the site and when they were getting close to the smelter in the morning.

Other areas identified as being of concern were a few of the **crib rooms,** which turned out to have very high readings of lead. This was brought to the attention of the management, resulting in the crib rooms being cleaned more often, and the cleaners wearing respirators.

As mentioned earlier, another concern was the fact that at least one person was caught **eating chocolate bars out on the plant.** It was suggested that management have a discussion with him.

In addition, some of the **workshops**, where the maintenance staff were not required to wear respirators, had high dust levels. This was clearly not the right advice.

Extended Data Logging

During our regular visits to the smelter, and after continuous feedback from the employees/SE400 users, we realised that there were certain parts of the plants that were very high dust areas. The whole site was being dust monitored regularly. Management had set up dust monitoring equipment on site and had identified all the parts of the plant where respirator wear was to be compulsory. Towards the end of the six-month project, these areas were extended drastically, leading to compulsory respirator wear almost throughout the entire lead smelter, except for inside the offices that, supposedly, were clean.

To identify labour-intensive jobs and jobs where the users truly required positive pressure respirators, we started carrying out Extended Data logging. This means that we connected a data logger to the SE400 units.

The Extended Data logger measures the peak airflow a person breathes while at work. The data logger measures the peak airflow 50 times per second, that is, at a frequency of 50 Hz. At this frequency, the extended data logger has a capacity of performing continuous logging for a period of close to 90 minutes.

After the work was carried out, the SE400 user would hand in the extended data logger box. The collected information would then be downloaded to a computer using our SE400 SE-EDL software. The software downloads the information to a file and then, with the help of a graphing tool in the software, puts all the peak airflow measurements onto a graph. This graph shows the peak airflows measured in litres/minute on the y-axis and the time in seconds or minutes on the x-axis. When the entire 90-minute work period is displayed, the units on the x-axis become minutes simply because of the limitations of the page size. The software calculates the following:

- Total User Volume (litres)
- User volume above a certain percentage
- User volume below a certain percentage
- Total filter volume (litres)

- System volume (%)

Other factors that can be calculated with the SE-EDL software are available in the option section, in what we call Volume Calculations (litres). In this section we are able to place a constant airflow line at say 150 litres/minute and select the flow supply volume of the PAPR. The software then calculates the amount of air that went through the filters that would have been outside the capacity of a conventional PAPR (Powered Air-Purifying Respirator.)

During some labour-intensive jobs, the wearer could show as high a percentage as 20–30% of the air he was breathing being outside the capacity of a conventional PAPR.

Below is a list of jobs that were data logged.

Date			**Type of Work**
02/02/01	1	K	Cleaning a blocked Rost hopper as well as a blocked Vibrator.
28/2/01	2	C	Work on a pump, oxycutting, manual work doing up nuts and bolts, fitting work
02/02/01	3	M	Showing and throwing calcium magnesium bars into calcium basket, skimming "PA2" with big spoon.
02/01/01	4	L	Jack hammering
03/01/01	5	Q	Cleaning sinter plant
27/2/01	6	J	
27/2/01	7	B	Work on computer, walking around
03/02/01	8	P	
28/2/01	9	I	Showling work, accdg to person not to much and not to hard
31/01/01	10	N	Checking lubrication line etc and changed a v-belt.
03/01/01	11	H	Driving Bobcat
03/01/01	12	G	
31/01/01	13	O	Inspection work, not hard work at all
28/2/01	14	E	Cleaning, very light work
28/2/01	15	R	
27/2/01	16	D	Forklift driving, alloying, taking samples in pan, walking around
03/01/01	17	A	Driving forklift, move lead around, stack it, very light work
28/2/01	18	F	Forklift driving,

Based on the above results, we could identify the jobs that really did require a positive pressure respirator.

We also offered the lead smelter to carry out this type of testing on a bigger scale. They have seriously considered video filming the testing, as well as attaching heart monitors to the workers during monitoring.

SE-Data

To manage the whole project, we set up a very comprehensive spreadsheet, in which we entered every comment from users and other company employees. We also noted down specific information about each project participant, such as age, weight, length of employment, smoking habits, equipment given, etc.

All this information was later on transferred to our SE-Data database that manages respiratory protection systems for companies. The software also alerts management when, say, one person's lead results are due, or when the filters on his unit need to be changed, among other things.

The SE400 positive pressure respirator system also has a configuration section which enables the unit to be programmed emit an LED light and sound the buzzer when the filter needs to be changed. It also emits a light signal of another colour when the batteries need to be changed, or if the wearer for any reason should breathe more than about 450 litres/minute.

Another section of the SE-Data is our very comprehensive chemical database in which extensive chemical, hygienic, toxicological and first-aid data is available on various chemicals and particles. This section was also used at times to learn more about the contaminants within the smelter.

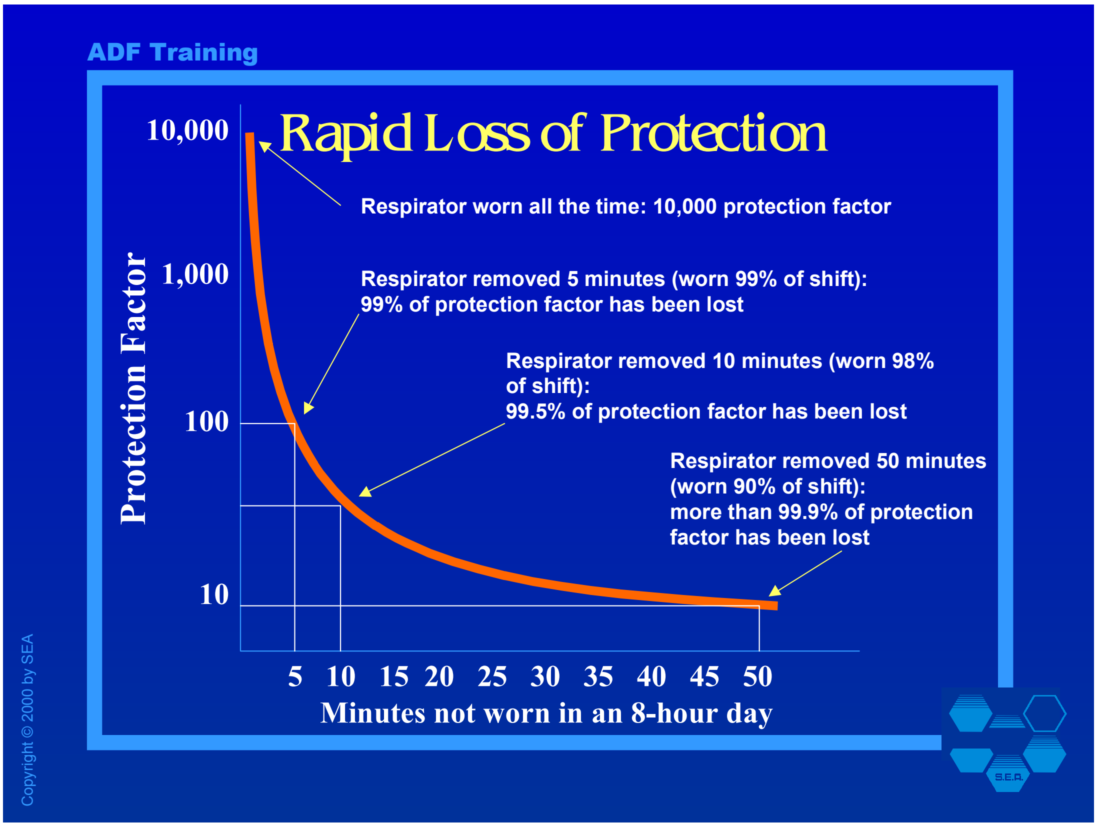
In the PPE Respiratory section we can carry out gas filter life calculations.

The calculation model can handle **adsorption of organic vapours on pure activated carbon (class A)**. Unfortunately, sulphur dioxide is captured by chemisorption on impregnated activated carbon, for which there is no calculation model. This is described more fully in Lennart Backman's paper, *The practical use of some existing models for estimating service life of gas filters*,[ref 6] which can be downloaded from the SEA web site.

CONCLUSION

There was a very clear indication that those SE400 users who kept their mask on during the majority of their shift had very high lead reductions. In other words, the SE400 unit was protecting them 100% of the time they were wearing the respirator. Therefore, it is critical to also encourage 100% wear time. I refer to the wear time graph below.

Wear time Graph



Even the Centre for Disease Control, in the 1999 publication *TB Respiratory Protection Program in Health Care Facilities: Administrator's Guide,* (ref 7) clearly identifies that PAPRs (Power Assisted Air Purifying Respirators) are known to provide an inadequate air supply at high workloads due to over-breathing.

What I have experienced in the past two years in this industry, and what I find most frightening, is how many people in the industry actually have been led to believe that PAPR actually stands for a Positive pressure Air Purifying Respirator.

One manager for one of the larger asbestos removal companies in Australia was very surprised when told that this is not what PAPR means. He told me he had used them for so many years in asbestos removal work in the belief that he was using a positive pressure respirator.

The fact is that with today's advanced technology we can and we should measure the actual performance of respirators. We should not guess anymore. We should know when and for how long the users were actually protected. This is the only way we will have the true picture. Having this information at hand for the respirator wearers also helps them to understand why they need to keep the mask on all the time during their time in a contaminated area.

REFERENCES:

1. Cowley, S., Hose, A., (Hyman, C. [ed.]), 2001, *Hazard Management for PPE Suppliers — Learning Tasks*, VIOSH, Univ. of Ballarat, Australia, p. 102
2. *TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents, Biological Exposure Indices*, 1996, Am. Conf. Gov. Ind. Hyg., Cincinnati, p. 25
3. *TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents, Biological Exposure Indices*, 1998, Am. Conf. Gov. Ind. Hyg., Cincinnati, p. 44
4. *Accident Prevention Manual for Industrial Operations*, 1959, (4th ed.), National Safety Council, Chicago, p. 4-2
5. *AS/NZS 1716:1994 Australian/New Zealand Standard: Respiratory Protective Devices*, 1994 Joint publ. Standards Australia, Sydney & Standards New Zealand, Wellington
6. Backman, L., 1997, *The practical use of some existing models for estimating service life of gas filters: Calculation of Adsorption Capacity and Breakthrough Times*, Safety Equipment Australia, URL: < http://www.sea.com.au/docs/papers/isrplb1.html >
7. *TB Respiratory Protection Program in Health Care Facilities: Administrator's Guide*, 1999, US Dept of Health & Human Serv. — Center for Disease Control (NIOSH), URL: < http://www.cdc.gov/niosh/99-143.html >