# Best Practices in Production, Sampling, and Testing of Breathing Air

**2008-WH-00064**

10/14/2008-10/31/2010

Russell Dills
Russ1@u.washington.edu

University of Washington
Department of Environmental and Occupational Health Sciences
01/20/2011

Author of report
Russell Dills


*Funding and support for this project has been provided by the State of Washington, Department of Labor & Industries, Safety & Health Investment Projects*.

# PART I

*Final Report Narrative*

| Organization Profile | For awarded organizations, to include partners and collaborators, provide a brief description of each organization. Mission, vision, and purpose of the organizations may be valuable to include. |
|---|---|

Our mission is to:
1) provide consultative and analytical services to employers and labor in Washington State. Our expertise is in chemical hazard identification, monitoring, and analysis.
2) support training of industrial hygiene and occupational medicine professionals in chemical hazard assessment.
3) research and develop new analytical and sampling methodologies for workplace chemical hazards.

The Environmental Health Laboratory has provided complimentary consultation and analytical services in industrial hygiene to labor and employers in Washington State since 1951. The Laboratory has been accredited by the American Industrial Hygiene Association since 1977.

| Abstract | Present a short overview of the nature and scope of the project and major findings (less than half a page) |
|---|---|

In response to queries on alternatives to high-pressure sampling of breathing air and lack of independent information on the accuracy, functionality, durability, and safety of commercially available breathing air quality assessment kits, the Environmental Health Laboratory (EHL) at the University of Washington evaluated six representative breathing air sampling kits. These were tested in the laboratory and also by personnel at three fire departments and one commercial diving company.

The absence of a regulatory requirement for laboratory proficiency in breathing air testing likely contributes to measurement deficiencies. For example, one set of results from a commercial testing lab found that samples containing no oxygen met OSHA standards for breathing air. The EH Lab was unable to demonstrate that water concentration could be successfully measured in fire-fighter breathing air by using commercially available low-pressure sampling kits. We found that indicator tubes did not always agree with laboratory measurements of carbon dioxide and water

vapor. These tubes do not meet NFPA requirements for accuracy.

| Purpose of Project | Describe what the project was intended to accomplish. |
|---|---|

The goals of the project were to:

1) evaluate commercial breathing air measurement and sampling systems
2) determine the likelihood of correct and safe operation of the systems
3) provide information on breathing air quality regulations, the basis of quality in analysis, and the importance of quality control in measurement.
4) provide information on problems associated with the production of compressed breathing air

| Statement of the Results | Provide a clear statement of the results of the project include major findings and outcomes |
|---|---|

Goal 1) Six commercial breathing air measurement kits of different designs were evaluated. One kit had two variations—one for field-testing and the other for collecting a sample for laboratory analysis. Another kit was solely for field-testing. Five kits had a container in which samples were collected for laboratory testing of the breathing air. To accomplish, this goal the Laboratory developed methods to measure breathing air contaminates in low pressure, low volume samples.

Only two of the kits used a container for collection of an air sample for measurement of water vapor; one was based on a 30 mL plastic medical syringe and the other was a proprietary aluminum canister. Based on our laboratory tests and results from the vendor's laboratory tests of blind samples, we were unable to show that water vapor at low ppm (parts per million) levels—around the regulatory limit—could be successfully measured using these kits.

The kit based on a syringe was prone to leaking. Results from the vendor's laboratory for gases with regulated concentrations were in significant disagreement with the known concentrations in the submitted samples (oxygen, carbon dioxide, carbon monoxide). For example, oxygen levels compatible with life (~ 20%) were found in samples containing only ppm levels of oxygen. As a result, this kit would not be recommended for use.

EH Laboratory tests concluded that sample results from the vendor laboratories for the other four container-based kits could be successfully used for the measurement of gases other than water vapor.

The kits varied in complexity and ease of use. Fire department and commercial diving company personnel rated the kits in these and other parameters.

Four kits utilized indicator tubes for field-testing of water vapor in fire fighter breathing air samples. Based on comparison to laboratory instrumental analysis, the water vapor measurements using these tubes do not appear to meet NFPA requirements for accuracy or precision but there are no regulatory requirements for accuracy or precision. The kit solely for field-testing used multiple components for controlling the flow rate of the breathing air being sampled. The long sample path and short sample time (per kit instructions) likely contributed to its gross overestimation of the water vapor concentration. This kit would not be recommended for use in its measurement. Also, by the design it appears that oil mist would contaminate the device and diminish in concentration before reaching the oil mist indicator tube.

Goal 2) Through both field-testing and laboratory testing, the correct and safe operation of the kits was evaluated. In both the field and laboratory, we found that the syringe system could eject the plunger under pressure when operated according to instructions. Likewise, in another kit one of the indicator tubes was prone to ejection because of its length. Both events are operator hazards.

Goal 3 and 4) We have produced two instructional documents which are on line at our Department's website. One is scientific and technical and the other has been written to be more broadly readable. We present results, background on regulated components of breathing air, factors in choosing a laboratory, and issues involved with breathing air generation.

Link: http://depts.washington.edu/envhlth/resources/practice.php

| **Evidence of the results** | Demonstrate evidence of how well the results met or fulfilled the intended objectives of the project. |
|---|---|

The link provided above is evidence of the results being disseminated as part of the objectives. We will notify our contact at the WA State Fire Mechanics Association (WSFMA) and other groups of the availability of this information. We presented the results at the 2010 Northwest Occupational Health Conference (NOHC), which reached industrial hygienists and other workplace health professionals.

We were unable to meet the schedule for presentation at the WA State Association of Fire Chiefs annual meeting. WSFMA canceled our presentation at their annual meeting (double booked time slot).

| **Project's promotion of prevention** | Explain how the results or outcomes of this project promote the prevention |
|---|---|

| | |
|---|---|
| | of workplace injuries, illnesses, and fatalities? |
| There are no regulations on laboratory or kit performance for breathing air testing. The NFPA does have code covering laboratory performance but no organizations are mandated to follow this code. We have demonstrated that variation in performance exists to the extent that breathing air incompatible with life would "pass" as being acceptable. Reliable vendors and kits for measurement for breathing air exist and we provide information on how to evaluate testing services so the consumer (e.g. fire departments) can make informed choices.<br><br>Based on the results from our testing and the scientific literature we question how any low-pressure device, including indicator tubes, can successfully measure water vapor at the regulatory concentration in fire fighter breathing air with satisfactory accuracy and precision. This may be a matter for the NFPA to find a practical solution. | |

| Relevant processes | Specify all relevant processes, impact or other evaluation information which would be useful to others seeking to replicate, implement, or build on previous work. |
|---|---|
| The laboratory processes are technical and will be described in a scientific paper, which is a reasonable forum for those working on the technical issues. Other than that standard statistics were used. | |

| Lessons Learned | Provide information on lessons learned through the implementation of your project. Include both positive and negative lessons. This may be helpful to other organizations interested in implementing a similar project.<br><br>*Lessons outlined should not relate to SHIP grant processes.* |
|---|---|
| Some vendors did not want to share laboratory processes, which could have facilitated some analytical method development required for the project. Customer service at vendors varied in quality and acquisition of kits needed more monitoring than we provided, in some cases. | |

| Measures to judge success | If relevant, state what measures or procedures were taken to judge whether/how well the objectives |
|---|---|

| | |
|---|---|
| | were met and whether the project or some other qualified outside specialist conducted an evaluation. |
| Outside evaluation of results and processes will occur during the peer review process of the scientific paper that will be submitted to either a fire safety or industrial hygiene journal. | |

| | |
|---|---|
| Uses | How might the products of your project be used within the target industry at the end of your project?<br><br>Is there potential for the products of the project to be used in other industries or with different target audiences? |
| This project indicates that quality of measurement should be included in breathing air assessment. There is a clear need for a solution to measurement of water vapor at low concentration and pressures. Any industry or service segment that uses compressed breathing air can use the information. | |

| | |
|---|---|
| Product Dissemination | Outline of how the products of the project have been shared or made transferrable. |
| Described in Evidence of Results | |

| | |
|---|---|
| Feedback | Provide feedback from relevant professionals, stakeholder groups, participants, and/or independent evaluator on the project. |
| The presentation at NOHC received many compliments (verbal). | |

PART II

# *SAFETY AND HEALTH INVESTMENT PROJECTS*
## *SHIP Final Expenditure Report*
## *Budget Summary*

| | | | |
|---|---|---|---|
| **Project Title:** | **Best Practices in Production, Sampling, and Testing of Breathing Air** | | |
| **Project # :** | 2008-WH-00064 | **Report Date:** | 10/31/10 |
| **Contact Person:** | Russell Dills / Rosie Schaffer | **Contact #:** | 206-543-3263 / 206-543-4253 |
| **Start Date:** | **10/14/2008** | **Project Completion Date:** | 10/31/10 |

| | | | |
|---|---|---|---|
| **1.** | **Total budget for the project** | | **$ 118,482** |
| **2.** | **Total SHIP Grant Award** | | **$ 118482** |
| **3.** | **Total of SHIP Funds Used** | | **$ 118,482** |
| **4.** | **Budget Modifications (if applicable)** | | **$ 0** |
| **5.** | **Total In-kind contributions** | | **$ 0** |
| **6.** | **Total Expenditures ( Lines 3 + 4 + 5)** | | **$118,482** |

Instructions:

- Complete the Supplemental Schedule (Budget) form first (on the next page).
- The final report must include all expenditures from date of completion of interim report through termination date of grant
- Indicate period covered by report by specifying the inclusive dates
- Report and itemize all expenditures during specified reporting period per the attached supplemental schedules
- Forms must be signed by authorized persons (see last page)
- Forward one copy of the report to (**Name), SHIP Project Manager, PO Box 44612, Olympia, WA 98504-4612**.

# *SAFETY AND HEALTH INVESTMENT PROJECTS*
## *SHIP Final Expenditure Report*
## *Supplemental Schedules (Budget)*

**Project Title:**
**Project # :** **Report Date:**
**Contact Person:** **Contact #:**
**Total Award $:**

**ITEMIZED BUDGET --** How were SHIP award funds used to achieve the purpose or your project?

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **A. PERSONNEL** | $78,741 | $78,516 | $225 |

Explanation for Difference and other relevant information:

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **B. SUBCONTRACTOR** | $0 | $0 | $0 |

Explanation for Difference and other relevant information:

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **C. TRAVEL** | $2,230 | $2,391 | ($161) |

Explanation for Difference and other relevant information:

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **D. SUPPLIES** | $26,730 | $26,808 | ($78) |

Explanation for Difference and other relevant information:

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **E. PUBLICATIONS** | $10 | $10 | $0 |

Explanation for Difference and other relevant information:

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **TOTAL DIRECT COSTS** | $118,482 | $118,482 | $0 |

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **INDIRECT COSTS** | | | |

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **TOTAL SHIP BUDGET** | | | |

| | Budgeted for Project | Amount Paid Out | Difference |
|---|---|---|---|
| **F. IN-KIND** | | | |

Explanation for Difference:

PART III

## Attachments:

| | |
|---|---|
| Presentation at NWOHC | NWOHC.pptx |
| Technical version of brochure | Breathing air Brochure - Long.pdf |
| Non-tech. version of brochure | BreathingAirReport1.31.11.pdf |

**REMINDER!!**: All products produced, whether by the grantee or a subcontractor to the grantee, as a result of a SHIP grant are in the public domain and can not be copyrighted, patented, claimed as trade secrets, or otherwise restricted in any way.