Commercial Opportunity

Gas Dilution Apparatus

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THE CHALLENGE

Improvements in respirator mask design and fit have outpaced aerosol based test systems such that they are no longer able to accurately determine upper limits of protection. The particle counters employed by such systems are unable to resolve the high aerosol challenge concentrations necessary due to co-incident counting effects. Dilution of the challenge concentration by a known factor so that the particle count falls within the reliable counting range of particle counter represents a potential solution. However, dilution apparatus developed for this purpose generally rely on mixing known amounts of particles with known volumes of clean air. Such techniques are inherently unreliable in that over time, environmental and other factors lead to changes in the dilution and are often incapable of providing the high levels of dilution required.

The importance of the accurate dilution goes beyond mere respirator testing, having application in fields as diverse as anaesthesia (medical gases and vapours), instrumentation (trace calibration gases), olfactometry and industrial lasers (assisting and lasing gases).

THE DSTL INNOVATION

The UK MoD's Defence Science & Technology Laboratory (Dstl) has developed a self-calibrating apparatus and method for the dilution of an analyte containing fluid incorporating novel venturi pump dilution stages. These dilution stages are fed with diluent gas on the positive side (e.g. clean air or nitrogen) and are connected to the concentrated analyte containing fluid on the vacuum side by a laser-cut flow control aperture that is capable of providing dilution factors in excess of 100 for sub-micron aerosols and 1000 for gases within a single stage.

In the first mode of operation, "calibration", the system utilises (at least) two dilution stages connected in series such that the output of one stage provides the input to the next (see Figure 1). A detector is then used to determine the concentration of the analyte at the output of each stage and hence the **dilution factor of the second stage** as the ratio of the two. The purpose of the first dilution stage is solely to bring the concentration of analyte within the range of the detector e.g. a particle counter, flame photometer or gas chromatograph mass spectrometer.

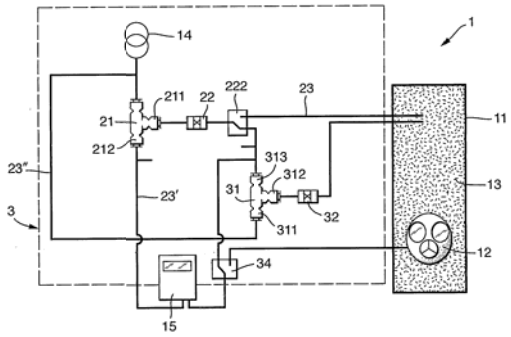

Figure 1 - The Gas Dilution Apparatus in "calibration" mode comprising: air pump (14), aerosol (13), venturi devices (21, 31), flow control aperture (22, 32, switchable valves (222, 34) and detector (15).

In the second mode of operation, "testing", the analyte containing fluid is connected directly to the vacuum side of second dilution stage and the detector used to determine the concentration of the analyte at the output the second stage. The **concentration of analyte in the original fluid** is then given by the product of the dilution factor of the second stage and the concentration of the analyte at the output of the second stage.

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The Dstl invention is particularly advantageous in that it enables the rapid and automated calibration of fluid dilution equipment in situations where the dilution factors may vary over time e.g. due to changes in temperature, venture supply air flow etc. The apparatus is software controlled and is very compact with dilution factors of between 2 and 10,000 easily achievable in a simple two stage system. Additional stages can be "daisy-chained" together in a configurable fashion to produce even higher dilutions to provide gas/aerosol concentrations spanning a number of orders of magnitude. Further, for a given venture flow rate, the dilution factors are consistent over a very broad range of analyte concentrations (see Figure 2).

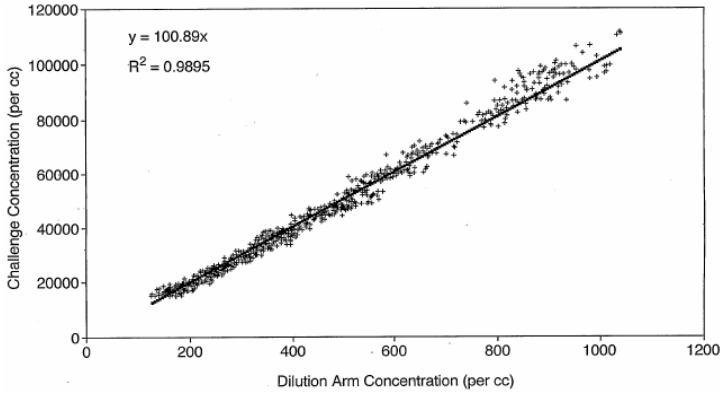

Figure 2 - A graph of aerosol challenge concentration versus dilution concentration, showing an essentially linear relationship over a wide range of starting concentrations.

Improved accuracy can be achieved by the use of a mass flow controller to meter the supply of diluent gas to the positive pressure arm of each venturi pump dilution stage.

In addition to measuring calibrated dilution factors and analyte concentrations to determine the protection factor afforded by a respirator under aerosol challenge, the apparatus can be used to:

- **produce well defined gas (or aerosol) mixtures** by diluting a high concentration feedstock gas with a second dilution gas (e.g. air, nitrogen, water vapour etc) through any number of in-series dilution stages to produce the required degree of dilution.
- **enhance the performance of gas (or aerosol) detection devices** by incorporating a calibrated dilution stage to extend an instrument's range or permit the use of a more robust detection technology.
- **rapid self-assessment of instrument calibration** by comparing the instrument response against the calibrated outputs from a range of venturi dilution stages.

THE OPPORTUNITY

The reliable and accurate dilution of gases is a critical component of many applications in high value healthcare and industrial sectors. For instance, the global anaesthesia equipment market was valued at $600m in 2006, the general laboratory speciality gas market at $270m in 2005 and the industrial laser speciality gas market at $40m in 2005. In addition, the testing and calibration of gas analysers presents another major opportunity with over 140,000 such detection units produced each year in a market valued at $278m in 2005. The Dstl technology offers a simple but novel solution to gas dilution issues in these sectors, offering improved accuracy, stability and dynamic range.

Dstl has undertaken an extensive programme of research in connection with the gas dilution technology for which it owns the IP rights. These IP rights comprise a published PCT patent application (WO 2007/031772) and know-how in the form of system designs, test methodologies and test results as embodied in a number of technical reports and demonstrator units. The system is currently in use within UK MoD for respirator testing.

Ploughshare Innovations, the technology transfer company for Dstl, is seeking suitable licensees to develop the gas dilution technology and exploit it in new gas mixing, testing and detection markets.