Biological Safety Cabinets

Energy Efficiency Saves Resources

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Our world has infinite possibilities but finite resources. Over the last decade, successive energy, environmental and financial crises have reminded us repeatedly of the need to expend our resources wisely. This article addresses how to gain the important benefits of safety and improved work quality offered by Class II Micro-Biological Safety Cabinets (BSCs) while consuming resources most efficiently.

The Cost of Exhaust

Biological Safety Cabinets protect the operator, product and environment through the use of an inward flow of air at the front aperture and filtration of air circulated in and exhausted from the cabinet. The filters within the cabinet capture particles, but not gases. If BSCs are used with volatile toxic chemicals or radionuclides, it is recommended that the exhaust from the BSC be conveyed out of the laboratory through the buildings' air ducts, and this can be costly. Every cubic meter of air conveyed out of the building must be replaced to ensure balance. Energy is expended moving the air and the replacement air may need to be treated in some way for temperature or cleanliness. When researching low flow fume hoods in 2003, Mills and Sartor of Livermore National Laboratories in the United States estimated that the average annual cost of exhausted air was €2.08 per cubic meter per hour (CMH).

There are three opportunities to reduce the external exhaust requirements of BSCs. First, review the contaminants and the application to be used in the BSC. The effectiveness of HEPA filtration used in BSCs is not always fully appreciated. Some users may request an externally exhausted BSC to handle biological hazards, when this application can be adequately addressed by the HEPA filters within the BSC.

Second, consider the amount and frequency of the need for externally exhausted BSCs. Rather than installing ten externally exhausted BSCs in a laboratory, it might be possible to use seven BSCs without external exhaust and two or three shared BSCs with external exhaust. If an BSC user will only work with anesthetic gas once or twice a month, it is much more efficient to provide a standard BSC for normal use and arrange access to an externally exhausted BSC for the special procedures.

Third, it may be possible to reduce the non-operational external exhaust requirement. A typical 1.2 meter wide BSC connected to external exhaust requires a draw of 400 CMH. Over the course of seven days a constantly operating external exhaust for this typical cabinet would expel 67,200 cubic meters of air. If the BSC external exhaust can be closed when not in operation without disturbing the balance within the laboratory or operation of other devices, the same cabinet operated for 40 hours would only expel 16,000 cubic meters of air for a reduction of over 75%.

The feasibility of this depends on the complexity of the facility ventilation system. One may have a simple building with only a few externally exhausted BSCs or a building with many laboratories, high energy and heat loads, a wide variety of external exhaust devices and critical room pressurization specifications to manage environmental and product containment. The number of externally exhausted devices such as BSCs and other types of containment equipment may have an enormous combined exhaust. Advanced ventilation systems will use flow controls to minimize the total exhaust while meeting the requirements for every device in use and maintaining needed room pressurization. These systems are highly complex with very torturous interrelationships between temperature, pressure, supply flow, and exhaust flow.

While complex systems are often the most likely to see the benefit of reduced exhaust flow from an externally exhausted BSC, they are also the most diffi-

	Thermo Scientific MSC-Advantage	Traditional Alternative A	Traditional Alternative B	Traditional Alternative C	Traditional Alternative D
Power Consumption	200 Watts	810 Watts	1000 Watts	1150 Watts	1800 Watts
Lifetime Power Consumption 40hrs/week for 15 years	6 240 kilowatt-hours	25 272 kilowatt-hours	31 200 kilowatt-hours	35 880 kilowatt-hours	56 160 kilowatt-hours
Lifetime cost using 0.1412 USD/kWhr*	€ 691	€ 2 800	€ 3 457	€ 3 976	€ 6 223

***Key World Energy Statistics 2008 by International Energy Agency provides the retail price for electricity to industrial customers in US Dollars for twelve members of the European Union (Austria 0.1406, Czech Republic 0.1523, Finland 0.0952, France 0.0610, Hungary 0.1591, Ireland 0.1806, Italy 0.2550, Poland 0.1152, Portugal 0.1406, Slovak Republic 0.1709, Spain 0.0896, United Kingdom 0.1339). The average of those twelve members is 0.1412 USD or 0.1108 Euros/kWhr.**

cult to implement because of the system interrelationships mentioned above. But, if it is possible to only draw the external exhaust requirement of 400 CMH for the 40 hours per week the laboratory was operating, the external exhaust requirement and cost can be reduced by 75%.

The Cost of Power Consumption

BSCs use electricity to power the fans and blowers that move the air through the filters and provide cleanliness and containment. There have been huge advances in energy efficient BSC fans and blowers using brushless DC motors since 2002 resulting in operational energy reductions of 50 to 75%.

Table 1 shows the published power consumption for five 1.2 meter wide BSCs along with life time power consumption and cost given a life of 15 years and forty hours per week usage.

The Cost of Heat Output

The amount of electrical energy consumed is proportional to the heat produced. Externally exhausted BSCs generally dump any heat produced out with the BSC exhaust. Units that are not externally exhausted will release approximately 3,412 BTU or 3,600 kilojoules for every kilowatt of power consumed. This heat released into the laboratory may need to be cooled which can increase the total power consumption by up to an additional 30%.

Minimizing the non-operational energy consumption

When an BSC is in operation the blowers are at operating speeds and the fluorescent lights are on. Most BSCs are not in constant use and can be completely shut off when not in operation.

Some users and protocols require the BSC maintain cleanliness and containment even when not in active operation.

	Demanding BSC	Energy Efficient BSC	Savings
Non-operational exhaust	€ 633.90	€ 0.00	€ 633.90
Operational exhaust	€ 198.10	€ 0.00	€ 198.10
Non-operational power consumption (including additional 20% cost of cooling for non-externally exhausted BSC)	€ 722.74	€ 28.41	€ 694.33
Operational power consumption (including additional 20% cost of cooling for non-externally exhausted BSC)	€ 230.46	€ 55.31	€ 175.15
Total cost of exhaust and power consumption	€ 1,785.20	€ 83.72	€ 1,701.48

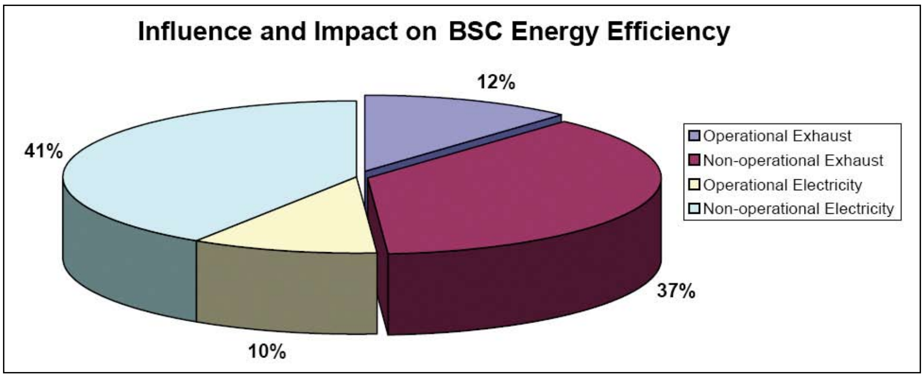
***Figures above assume both BSCs have 400 CMH exhaust, 45 watt power consumption for UV light. The demanding BSC consumes 1000 watts operational and 935 watts with fans on and lights off. Energy efficient BSC consumes 200 watts operational, 32 watts with reduced fans and lights off and 2.5 hour UV decontamination cycle. Generic assumptions are cost of €2.08 per CMH per year for external exhaust, €0.1108 per kilowatt-hour, 2080 operational hours per year, 6656 non-operating hours per year, 8736 total hours per year, and 250 UV decontamination cycles per year.**

Even in these cases, some reduction in energy is possible by turning off the fluorescent lights which can reduce the energy consumption up to 8% annually.

Some of the same advances in BSC motor technology reducing operational energy consumption also reduce non-operational energy consumption. Brushless DC motors have much more capability to vary speed providing some cabinets with a reduced flow or "night" mode where the BSC window is closed, the motor speed is reduced but still maintains cleanliness and containment in the work area.

Effective use of the germicidal light can also reduce non-operational energy consumption. The sample chamber of the BSC is wiped down at the beginning and end of each work day and between experiments. Some BSC users also use the germicidal light to fully decontaminate the sample chamber overnight. This assures that any small droplets of biological materials which may have been splashed or sprayed onto the interior surfaces of the BSC sample chamber and missed during the wipe down will be inactivated.

A "Bacteria Destruction Chart" from Ultra-Violet Products lists the exposures required to sterilize various biological



agents. Some BSCs have timers on their UV lights allowing one to select the amount of time in the UV decontamination. Using the customary assumptions for UV intensity within an BSC and UV lamp life, a 2.5 hour UV decontamination cycle would provide the required exposure for the most resistant organism listed and would extend the life of a UV bulb from one to eleven years.

Summarizing Energy Efficiency in the BSC

We have listed various ways to reduce external exhaust and reduce the power consumption of our BSCs. The challenge is to identify the best opportunities to improve the energy efficiency of the BSCs we need. The chart below contrasts the energy savings between a worst case and a more efficient BSC. The worst case is a more demanding externally exhausted 1.2 BSC using traditional fans that are always left on with germicidal lights when not in use. The more efficient BSC is a non-externally exhausted 1.2 BSC with energy efficient fans and timed UV decontamination cycles. The assumptions are listed below the table.

The first row labeled "Non-operational exhaust" shows if a way could be found to avoid drawing external exhaust when the BSC is not in use, there could be a savings of €633.90 per year. The second row labeled "Operational exhaust" shows if a way could be found to replace the externally exhausted BSC with a non-externally exhausted BSC by reviewing the nature of the materials being used or by sharing an exhausted BSC, there could be additional savings of €198.10 for a total of €832 per year. The third row labeled "Non-operational power consumption" shows that if a reduced flow mode is used to maintain cleanliness and containment when the BSC is not in operation, there could be a savings of €694.33 per year. The fourth row labeled "Operational power consumption" shows that if energy efficient blowers are used, there could be a savings of €175.15 per year. The potential savings could reach €1 701.48 or over 95 %. For BSCs that are not externally exhausted, the possible savings from energy efficient fans can reach €869.48 or over 90 %. The chart below illustrates the savings with the non-external exhaust savings to the left.

The convenient truth of BSC energy efficiency is that the benefits of cleanliness and containment can be provided in a much more efficient manner than in the past. Through wise and appropriate use or external exhaust and the selection of energy efficient BSCs it is easy to make choices good for the BSC user and the world.

Reference

[1] Mills E. and Sartor D.: Energy 30(10), 1859–1864 (2005)

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