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WHAT MAKES A BIOLOGICAL SAFETY CABINET SAFE

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Abstract

Some people may not appreciate it, but a biological safety cabinet is a more complicated device than simply a large metal box with a fan and some HEPA filters. Similarly, keeping a safety cabinet performing safely is also a more complicated process than simply "changing the filters regularly".

This technical paper was written to address some of these myths and fallacies, and to educate laboratory scientists, cabinet users, facility safety officers, and other people - in the hope that the knowledge shared here will improve the safety of our environment for the common good.

These are some of the various performance factors that make a biological safety cabinet safe:

1. HEPA / ULPA filtration

The filters used in the cabinet must be of the appropriate filtration efficiency. If not, they will fail to contain biological hazards. In addition, the filters should be tested by the cabinet manufacturer to ensure they are leak proof, after they are installed onto the cabinet at the factory. Since these filters are very delicate items (which can be damaged easily by as much as a light impact with the ground), this is important to ensure no damage has occured during earlier transportation and handling. For the same reasons, the filters should also be tested on site in the laboratory where the cabinet is installed.

In addition, many fallacies exist about filter efficiency declarations and ratings. For more information, please ask for the Esco technical paper concerning this subject.

(Esco's filters are rated at 99.9998% at 0.3 microns, the highest in the industry. All filters are tested for leaks not only by our filter supplier - the largest filter manufacturer in the world - but also at our factory after installation onto our cabinets.)

2. Precision control of airflow

The airflow pattern in the cabinet must meet both qualitative and quantative performance criteria.

a. Qualitative / directional airflow

Airflow must be inward (from the laboratory into the cabinet) at all points in the work access opening. This aspect must be designed from the ground up, but must also be validated on every cabinet produced by the manufacturer.

(Every Esco cabinet is tested for airflow patterns at our factory after production)

b. Quantitative / airflow velocities

The airflow velocities in the cabinet must be of a suitable magnitude. It should not be too excessive (which can cause turbulence and loss of containment). However, it should not be too low as well (insufficient protection since contamination can escape easily from inside the cabinet to the laboratory). For every individual cabinet design, there exists an airflow velocity point at which the best safety is achieved. The manufacturer should test his own cabinet design to determine this airflow setpoint - which should then be set and maintained for all cabinets produced.

(Every Esco cabinet is tested for airflow velocities at our factory after production)

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3. Containment of the enclosure

Containment refers to the ability of the cabinet / enclosure to contain all hazardous particles inside the working space without any escape through the front of the cabinet. Proper containment of a safety cabinet is primarily dependent on the airflow aspects (directional airflow, correct velocities) described above.

There is only 1 recognised way in the entire world to perform testing of containment on a safety cabinet in the field and after manufacture - the KI-discus test as specified in EN12469:2000. In addition, it should be noted that a cabinet can pass all the airflow tests but still fail the containment test.

(Esco is one of the few companies outside Europe with KI-discus testing capabilities. We maintain a statistical testing program by which a cabinet from a statistical sample of units manufactured, is individually tested at the factory with the KI-discus test. In addition, all our safety cabinets have been type-tested and approved for containment with this method. Finally, many Esco cabinets have also been independently type-tested - in the most recognised international laboratories - using the microbiological method for operator protection.)

4. Air-tightness of the entire cabinet

The entire cabinet should be pressure and air tight to ensure no leakage of biological hazards through joints and seams. For example, the filters can have a very high efficiency, but on some cabinet designs, biological hazards could by bypassing the filters and leaking through joints in the body of the cabinet - and the cabinet as a whole is still unsafe.

(Esco's Dynamic Chamber design surrounds all contaminated plenums with negative pressure, even if a puncture or leaks develops in the cabinet shell, all contaminated materials are still directed through the filters. In addition, our cabinet external shell is itself pressure tight to 500Pa.)

5. Precision engineered components

It should not come as a surprise that components for biological safety cabinets have to be precision engineered to very close tolerances. For example, a difference of 1mm in the size of the perforation of the air slots (front intake grille, back perforation grille) in the cabinet can change the cabinet's performance parameters and cause it to fail containment tests. Also, since a safety cabinet is typically a very complex assembly of many parts (more than 100 parts per cabinet) this difficulty (for the manufacturer) is compounded.

(Esco has 20 years experience in precision sheet metal fabrication and electromechanical assembly. We control all manuacturing processes in-house to maintain the highest quality standards. All metal components are CNC fabricated in an automated manufacturing plant for absolute reproducibility.)

6. Electrical and mechanical safety

Considering the hazardous nature of work being performed inside a safety cabinet, additional requirements should be enforced for mechanical hazards (i.e. to avoid injuring the operator while working inside the cabinet, the effects of which can result in further exposure and injury to hazards). For the same reason the operator has to be protected against electrical hazards.

(Esco cabinets are designed in compliance with IEC 61010-1 for these general electrical and mechanical safety requirements. In addition, all cabinets are electrical safety tested at our factory after production. Other design features - for example, using tempered glass which does not shatter easily unlike regular glass - are also standard items.)

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7. Airflow control and monitoring system

In order to ensure the cabinet functions safely at all times it should be equipped with a control and alarm system to monitor all important safety parameters in particular airflow. This difficulty should not be under-estimated, since the manufacturer has to provide a system accurate and sensitive enough to measure the very low velocities encountered in a safety cabinet.

(All Esco safety cabinets are equipped with an airflow alarm and monitoring system using airflow sensing technology not only meeting accuracy requirements, but which can also compensate for fluctuations in ambient temperature.)

8. Physical testing and validation

As can be seen above, not only does the cabinet have to be designed for safe operation, but many physical tests / measurements are required to check that the unit is meeting these safety requirements. These tests must be performed by the manufacturer after the unit is constructed at the factory.

Many manufacturers may claim to test their products at their factory to these safety standards, but since physical testing of safety cabinets is a very precise science and encompasses many fields (aerosol generation and photometry, air velocity measurement, directional airflow validation, containment testing etc.), one cannot be sure the testing is done accurately and safely, unless these capabilities are accredited independently.

(In this aspect Esco is eminently qualified, since we maintain a full laboratory at our factory dedicated to these performance tests, with the latest and most accurate instrumentation. Our testing capabilities are accredited by the NSF Biohazard Cabinet Field Certifier program. Our entire testing set up is without any doubt the most comprehensive - and safest - in Asia.)

SUMMARY

It should be noted that since all factors are inter-related, the degradation of one performance factor alone can jeopardize the safety of the entire system. For example, a cabinet may have very high efficiency filters in excess of the standards, but if it does not meet containment requirements, the entire system is still unsafe.

Also it should be noted that the above performance factors constitute the minimum in terms of operator safety requirements, and do not encompass additional performance features offered by established international manufacturers like Esco. These performance factors also do not cover other "performance" variables in a cabinet such as protection of the product, protection of cross contamination etc. Finally, other important aspects, such as the need for regular field certification, and proper installation, are also not covered.

Finally, the best, quickest and most convenient way to ensure your cabinet is safe, apart from understanding all the above safety related aspects, is to ensure also the cabinet you purchased has been certified to a major international safety standard - one of the following:

EN 12469 (European safety standard for safety cabinets)
NSF 49 (American safety standard for Class II safety cabinets)
AS 2252.2 (Australian safety standard for Class II safety cabinets)
JIS K3800 (Japanese safety standard for safety cabinets)

On the subject of standards compliance and approval, some final warning to our readers:

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1. Beware of manufacturers who claim compliance to the safety regulations, always ask for proof (independent test reports).

2. Beware of manufacturers who claim compliance to other unrelated standards. For example, it is useless that a safety cabinet is made by an ISO 9001 company if it has not been tested to one of the above safety standards.

3. Ensure the independent authority testing the cabinet is accredited and qualified to do so.