



Discussion of Concurrent Balance Value of Class II, Type B1/B2 Biological Safety Cabinets

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The field certification of Biological Safety Cabinets (BSC's) as required in Annex F of the NSF/ANSI 49 class II biosafety cabinetry standard is based on the principle of replication. To assure the BSC is operating within its design and biological containment performance tested range, the field certifier is required to use the same test instruments and procedures as both NSF and the manufacturer have used during the biological containment testing (type testing) at NSF. This replication of both the test instruments and procedure assures the BSC user the level of containment performance established by the standard since its inception in 1976. However with the emphasis on replication and the use of specific test instruments and procedures, the airflow measurement results for the certification of BSC's can be suspect for other uses.

The selection of test instruments and procedures for the airflow measurement of BSC's has always had many challenges. This is especially true of class II, type B1/B2 BSC's that are direct connected to an exhaust system. The inflow measurement methods for these cabinets have in history been performed using many different methods.

Calculation of the inflow velocity from duct traverse measured air volume flow rate provides a consistent repeatable indication of inflow velocity provided that an accurate measurement of the exhaust duct airflow is available. This is not always the case due to the physical limitations of the facility. An accurate duct traverse requires a certain degree of velocity uniformity in the ductwork at the plane of the duct traverse. An ideal distribution would have 80 - 90% of the measurements greater than 10% of the maximum velocity. The worst distribution that could be considered is when no less than 75% of the velocity pressure measurements are greater than 10% of the maximum velocity (ASHRAE Std. 111-1988). This often requires a substantial length of straight ductwork upstream, and a lesser but still important section of straight ductwork downstream of the traverse plane. Such conditions often do not exist in field applications. When inflow velocity is calculated from measured exhaust duct airflow there is little confusion regarding the actual exhaust airflow since this value can be used as the basis of the inflow calculation.

Other methods were developed in the 1980's at the face of the BSC to avoid the duct traverse method and its requirements. The basic idea with these alternate methods was to straighten the inflow velocity enough to measure velocity in a grid pattern using a thermal anemometer. Two of the more popular methods included the use of a flow box that could be taped to the face of the BSC so all the air volume was directed through the box that aided in producing uniform air velocity distribution. The other similar method removed the front grill, inverted the worktray and placed it just behind the work access opening. This again aided in producing uniform air velocity distribution for a thermal anemometer measurement. However, these methods were not universally accepted, so in the late 1980's an NSF joint committee task group was formed to review BSC inflow measurement methods.

One of the methods evaluated was the use of Direct reading Instrument Measurement or (DIM) method. The DIM method uses a capture hood at the face of the BSC that directs all airflow past a differential pressure velocity grid measuring inflow volume. This value can then be used to calculate inflow velocity. Application of the DIM greatly simplified the measurement of inflow velocity for all cabinet types especially direct connected and demonstrated excellent repeatability from cabinet to cabinet even by different technicians. The DIM method also is not affected by configuration of the exhaust ductwork for direct connected BSC's. So the DIM method was adopted into the 1992 revision of the NSF Standard 49 as the primary means to measure inflow volume calculating inflow average inflow velocity.

Through the 1990's, certifiers of BSC's used the DIM method for the field certification of BSC's following Annex F of the NSF standard 49. During this time, certifiers would sometimes work on new building projects where they noticed differences in the exhaust volume provided by the building air balancers and what they measured using a DIM. As discussed above, the DIM method was primarily chosen for its repeatability. However, accuracy of the DIM airflow measurement was reviewed as being acceptable with the NSF joint committee task group using data comparisons of duct traverse measurements and orifice plate's, it was not seen as an absolute requirement. When reviewing the application of the capture hood to the face of a BSC, due to the nature of the airflow at the sash opening and the restricting effect of the DIM, the accuracy of the measured value, relative to the actual airflow through the opening during normal operation of the BSC, is a topic for debate. However, as previously stated, uncertainty of the airflow measurement does not impact on the ability of the certifier to determine acceptable performance of the BSC. The certifying technician is merely seeking to replicate the conditions of the operating BSC that existed when the cabinet was biologically containment performance tested at NSF in which inflow volume measurements were performed utilizing the DIM method. Biological containment performance will be compromised if the original airflow measurements are not reproduced in the field.

However, uncertainty or accuracy is a concern for mechanical system designers, contractors, and balancing companies. The actual inflow air volume, in standard cubic feet per minute, is the value that must be used when sizing and designing exhaust and make-up air systems, when supplying and installing these systems, when adjusting and balancing the systems and when operating the building in day to day activities. Due to this uncertainty, ASHRAE thought enough of the situation to conduct a study through their Technical Committee TC 9.10 laboratory systems. The study evaluated direct connected Class II, type A2 and type B2 BSC's. The study involved taking multiple measurements (exhaust duct traverse, BSC face measurements of DIM, flow box and constricted access opening) to determine average inflow velocity of multiple cabinets and compare the results.

In simple terms, the results of the study did show that the DIM method was the most consistent and repeatable of all the methods and confirmed its use as the primary method for BSC inflow velocity measurement. The other BSC face methods also showed good general correlation to the DIM method and would be considered acceptable alternatives if needed. The duct traverse measurements showed very weak consistency and in turn poor correlation to inflow velocity. This was due to less than ideal access to duct work that provides the necessary straight duct runs required for good measurements. Velocity profiles were often noted as being non-uniform with wide ranges in velocity caused by turbulence. This being the case, duct traverse measurements would not be reliable enough for consideration in BSC face velocity determination. In addition to duct access, there is a higher level of technician skill and patience required for accurate traverse measurements than the other methods.

The study also found that the lack of correlation between airflow measurements at the BSC face and those performed in the duct indicates that the manufacturers NSF certification volume measurements are suspect for use by mechanical system designers, contractors and balancing companies. Alternate airflow data is needed which more closely correlates to the traditional airflow measurements performed by engineers and air balance professionals during the design, construction and management of the building ventilation system. The alternate airflow data or duct traverse measurements would be taken after the BSC has been set up and calibrated using the DIM method to provide this traditional airflow measurement data for the mechanical system designers, contractors and balancing companies. The traditional airflow measurement data should be referred to as the Concurrent Balance Value (CBV) and is defined as the following:

Concurrent balance value is determined by a duct traverse measurement method taken a minimum of 7.5 duct diameters downstream of a direct connected BSC at its nominal setpoint calibrated using the primary DIM method and capture hood removed. The static pressure is measured approximately 2 duct diameters above the BSC. Appropriate filter load and tolerance values are added to accommodate filter loading. These values shall be used for design and balance exhaust/supply HVAC requirements.

With the results of the ASHRAE study, the NSF standard 49 joint committee has agreed to publish the CBV in the NSF listings for biosafety cabinetry. This information will provide the mechanical system designers, contractors and balancing companies more relevant data for direct connected BSC's and hopefully minimize field testing discrepancies that have been encountered in the past.

The purpose of the technical bulletin is for information only. Being a member of the NSF 49 joint committee and ASHRAE TC 9.10 project monitoring sub-committee, the discussion within represents my perspective of the topic and does not represent the official opinion of either the NSF 49 joint committee or the ASHRAE TC 9.10 project monitoring sub-committee and should not be used as such.

References:

NSF/ANSI 49.2007.Class II (laminar flow) biosafety cabinetry. Ann Arbor, MI, NSF International.

ASHRAE Research Project 1212-RP: 2004.Airflow Measurement of Biological Safety Cabinets (Preliminary data). Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE Standard 111.1988.Practices for Measurement, Testing, adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigerator systems. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.