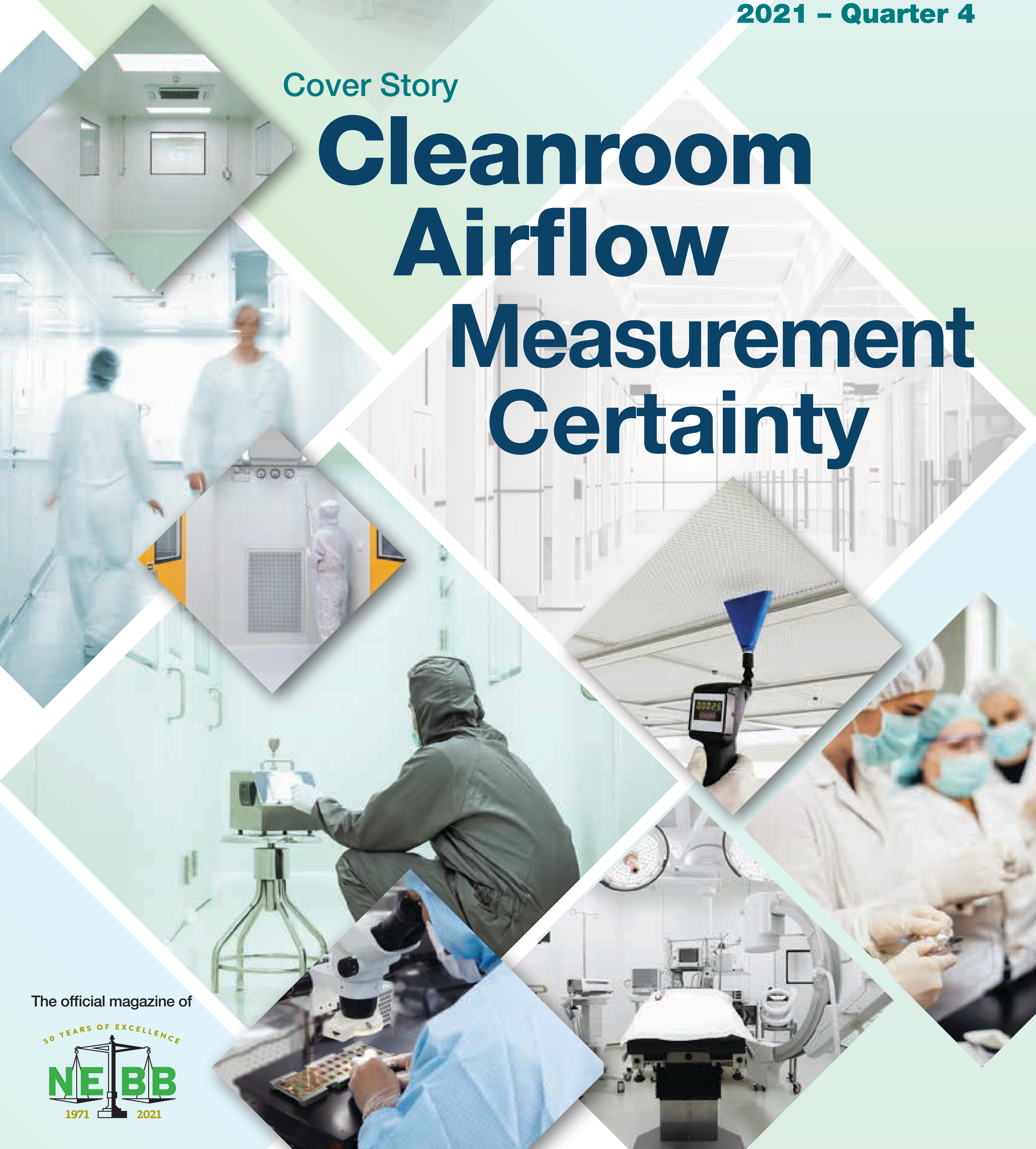
The NEBB Professional

2021 – Quarter 4

Cover Story

Cleanroom Airflow Measurement Certainty



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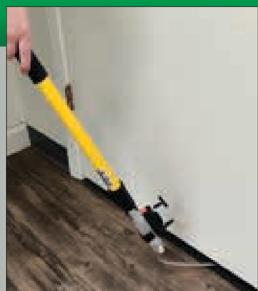

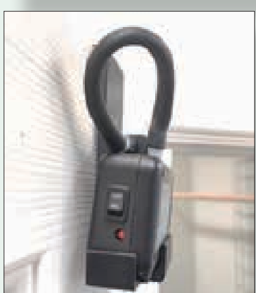

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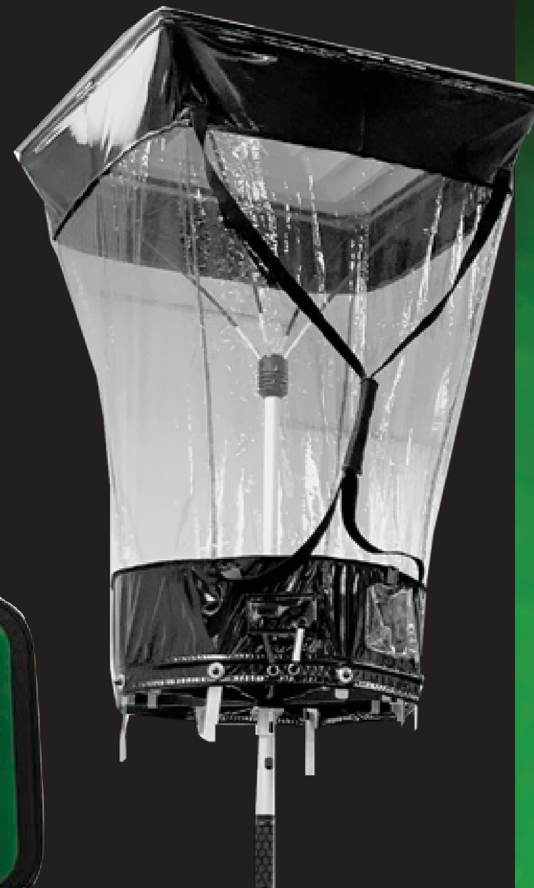

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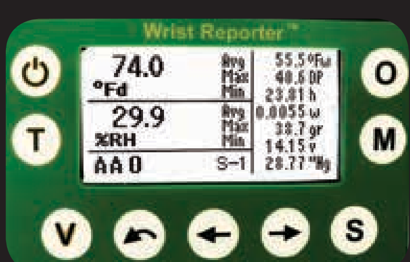

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PRESIDENT'S MESSAGE

Hello (Hola, Bonjour, Konnichiwa or even just ✋)

It is a great honor and privilege to be selected by the Board of Directors as the 2022 NEBB President. I would like to thank Amber for a year full of incredible achievements and for her leadership in guiding NEBB throughout 2021. I would like to thank the Board of Directors for their confidence in me, and I will strive to provide Servant Leadership as president, director, and volunteer!

As NEBB celebrated its 50th year just a few short weeks ago in Maui, we looked back at 50 years of challenges, changes, and innovations in our industry. In the conference welcome packet, there was a book titled, "50 Years of Excellence" that takes us on a journey through NEBB's history. We learned that NEBB started with just 6 chapters in 1971 – and now we have 24 chapters spanning multiple countries. As you read through this amazing book, you see just how awesome our volunteers have been to this organization!

Now we are poised to start our next 50 years, and, as we said at the annual conference, "We are focused, but not finished!" 2019 and 2020 were tough years due to the pandemic, but that did not stop NEBB from pushing forward, just as our Certified Firms, Professionals, and Technicians all did. In fact, our industry became even busier while demand continues to increase.

We've started several exciting projects and are now in a position to finish strong. Thanks to the outstanding leadership of Past Presidents, Board of Directors, and Staff, NEBB is currently the strongest it's ever been, and we are ready to launch new and exciting ventures over the next several years. One of the major projects nearing completion is the hands-on portion of the Robert Gawne Training and Education Center (NEBB TEC). Here we see opportunities to provide practical/experiential training and instruction for all NEBB members. From those just starting out in our field all the way up to senior level engineers, many of whom haven't had the opportunity to get their hands on equipment and systems. Our goal is to provide the true experience they seek for better understanding of field testing and the challenges they can encounter day to day.

The next project I want to introduce is the NEBB Learning Center (NLC), which is our new online eLearning platform. Through the NLC, we will be able to deliver live seminars, self-driven study courses, media presentations, and provide an online community where NEBBers come to learn! The NLC will act as our central hub for all course materials and will be the go-to place for anyone seeking to learn more about NEBB, or the various disciplines in which we offer certification and training. With recent travel restrictions, we realize the opportunity this will provide for those outside the continental US who can't make it to an in-person seminar. We want to make all NEBB Training as accessible as possible to all people!

Perhaps the most exciting news to share is that, during the Annual Conference in Maui, Jeff Schools was introduced as the new NEBB Technical Director. As a past President of NEBB and a volunteer who has served on countless committees and projects, Jeff brings a unique skill set and point of view to this position. I think I can speak for him when I say that he is very excited to hit the ground running! Jeff will personally oversee the completion of the NEBB TEC hands-on lab and play a vital role in the content provided through the NLC. If you attend a technical seminar in 2022, you are likely to see Jeff there helping, or maybe even teaching. Welcome aboard Mr. Schools!

In November of 2022 we will hold our Annual Conference in Charleston, South Carolina! The Belmond Charleston Place is located in the heart of Charleston's historic district and is steps away from the City Market. This 5-star hotel is where Southern charm meets timeless elegance! We hope you can join us for technical sessions, good food, and most importantly, a good time!

Jon

Jon Sheppard
NEBB President

MENSAJE DEL PRESIDENTE

Hola (Hello, Bonjour, Konnichiwa o simplemente ✋)

Es un gran honor y privilegio haber sido seleccionado por la Junta Directiva como el presidente de NEBB 2022. Me gustaría agradecer a Amber por un año lleno de logros increíbles y por su liderazgo guiando NEBB a través del año 2021. ¡Me gustaría agradecer a la Junta Directiva por su confianza en mí y voy a esforzarme en proveer liderazgo de servicio como presidente, directo y voluntario!

Al mismo tiempo que NEBB celebraba su 50 aniversario solo hace unas cuantas semanas en Maui, volvimos la vista atrás a 50 años de retos, cambios e innovaciones en nuestra industria. En el paquete de bienvenida de la conferencia, había un libro titulado "50 años de Excelencia" que nos lleva en un viaje a través de la historia de NEBB. Aprendimos que NEBB inició con solo 6 capítulos en 1971 – y ahora tenemos 24 capítulos abarcando múltiples países. ¡Conforme uno lee a través de este sorprendente libro, se da cuenta de lo asombrosos que han sido los voluntarios para esta organización!

Ahora estamos listos para empezar nuestros siguientes 50 años, y, como dijimos en la conferencia anual, "Estamos enfocados, pero no hemos terminado". 2019 y 2020 fueron años difíciles debido a la pandemia, pero eso no detuvo a NEBB de empujar hacia adelante, tal y como lo hicieron todas nuestras Firmas Certificadas, Profesionales y Técnicos. De hecho, nuestra industria se tornó aún más ocupada mientras la demanda continúa incrementándose.

Hemos iniciado muchos proyectos excitantes y ahora estamos en una posición para finalizar fuertes. Gracias al liderazgo sobresaliente de nuestros anteriores Presidentes, Junta Directiva y Staff, NEBB es actualmente más fuerte que nunca, y estamos listos para lanzar nuevas y emocionantes iniciativas en los próximos años. Uno de los mayores proyectos próximos a completarse es la sección "hands-on" del Centro de Entrenamiento y Educación de NEBB Robert Gawne (NEBB TEC). Aquí vemos oportunidades de proveer entrenamiento y experiencias prácticas, así como de formación para todos los miembros de NEBB. Desde aquellos recién iniciando en nuestro campo, hasta los niveles senior de ingenieros, muchos de los cuales no han tenido la oportunidad de colocar sus manos en equipos y sistemas. Nuestra meta es proveer la verdadera experiencia que ellos buscan para alcanzar un mejor entendimiento de las pruebas de campo y los retos que se pueden encontrar en el día a día.

El siguiente proyecto que quiero presentarles es el Centro de Aprendizaje de NEBB (NLC por sus siglas en Inglés), el cual es nuestra nueva plataforma de aprendizaje electrónico en línea. ¡A través del NLC, seremos capaces de brindar seminarios en vivo, cursos de estudio auto-dirigidos, presentaciones de comunicación, y proveer una comunidad en línea donde los miembros de NEBB, NEBBers, pueden venir a aprender! El NLC va a fungir como nuestra plataforma central para el material de todos los cursos y va a ser el lugar por excelencia para cualquiera que busque aprender más acerca de NEBB, o de las diferentes disciplinas en las cuales ofrecemos certificación y entrenamiento. Con las recientes restricciones de viaje, nos dimos cuenta de la oportunidad que esto va a brindar para aquellos fuera de los Estados Unidos continentales que no se pueden presentar a un seminario en persona. ¡Queremos hacer que todo el entrenamiento de NEBB sea tan accesible como sea posible a todas las personas!

Quizás, la noticia más emocionante para compartir es que durante la conferencia anual en Maui, Jeff Schools fue presentado como el nuevo Director Técnico de NEBB. Como anterior presidente y voluntario que ha servido en múltiples comités y proyectos, Jeff brinda un conjunto de habilidades y punto de vista únicos para esta posición. Creo que puedo hablar por él cuando digo que está muy emocionado de iniciar su trabajo con resultados. Jeff va a supervisar personalmente la finalización del laboratorio de práctica "hands-on" del NEBB TEC y va a jugar un papel vital en la entrega de los contenidos a través del NLC. Si usted asiste a un seminario técnico en el 2022, muy probablemente verá a Jeff ahí ayudando, o inclusive tal vez enseñando. ¡Bienvenido a bordo Señor Schools!

¡En noviembre de 2022 vamos a tener nuestra Conferencia Anual en Charleston, Carolina del Sur! El Belmond Charleston Place está localizado en el corazón del distrito histórico de Charleston y está a corta distancia del City Market. ¡Este hotel de 5 estrellas es donde el encanto sureño se encuentra con la elegancia eterna! ¡Esperamos que puedan acompañarnos para las sesiones técnicas, la buena comida y lo más importante, un buen momento!

Jon

Jon Sheppard
Presidente de NEBB

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Past President's Comments

It has been an extremely exciting year for NEBB with training at the forefront of the decisions being made. To start, NEBB has invested in a new online training platform, NEBB Learning Center (NLC) and has hired a new Online Training Coordinator to focus on content for and access to online courses. Please join me in welcoming Samatha Hawa to the NEBB family. It is exciting to have her onboard and I look forward to the future online training courses that will be available soon.

The next exciting news is the hiring of Jeffery Schools as the Technical Director. Jeff has been involved with NEBB for countless years and as the Past President he is an amazing fit for this position. He knows NEBB inside and out and is dedicated to making sure all the technical questions and needs are met. One main focus of Mr. Schools are the final touches and opening of the Robert Gawne Training and Education Center (NEBB TEC). The future looks bright with the options for online training and hands-on training that will soon be available.

If you have not checked out the new NEBB website I would do so now. It is another exciting piece of news we have. The website is modern, sleek and user friendly. When you are on the site check out the NEBB Bookstore where you can buy all of our publications including the NEW TAB Technician Manual as well as the Sound Home Study Course, which were both published this summer.

Looking for a shirt or hat, we will soon offer swag as well. As I mentioned, this has been an extremely exciting year for NEBB and I know next year will be just as exciting with Jon Sheppard taking over as the current President. I would like to congratulate him on his new role. Mr. Sheppard is so hard working and sometimes I wonder when he sleeps. He is always very detailed in what he works on and quality is of utmost importance to him. NEBB is in good hands with him as the leader. Finally, I would like to thank the Board of Directors and the EFC for the last year of support during my journey as President. It was an honor to serve as the NEBB President and I look forward to continuing to work with NEBB in the future.

Amber Ryman
Past President

A message from the editor
AUDREY P. KEARNS

As we near the end of 2021, we saw our business going thru the roof! Covid and all its restrictions did not slow us down but may have increased the need for what we do.

Those who attended the NEBB Conference in Maui, Hawaii, would agree, that it was an outstanding conference! We celebrated the 50th Anniversary of NEBB in a fabulous location and made memories not long forgotten.

In NEBB fashion, top notch forums and technical sessions were offered over 2 days.

We saw a changing of the guard with our first ever woman President Amber Ryman saying her farewells and 2021/22 President Jon Sheppard being inducted. Congratulations to both!

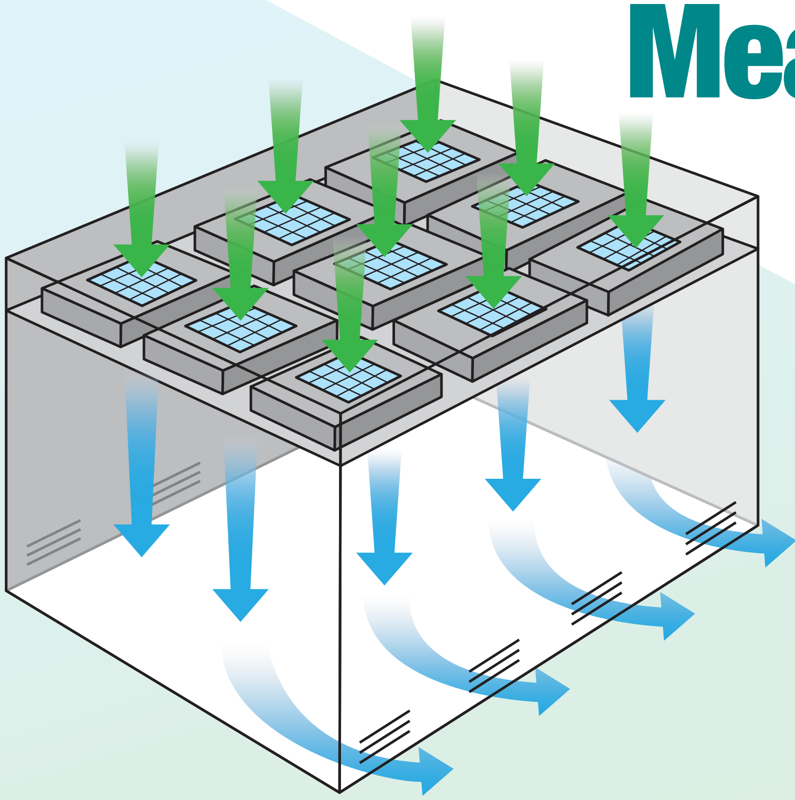
NEBB's new Technical Director, Jeff Schools was announced. Jeff will have his capable hands full in managing and directing the technical aspects of NEBB. Looking forward to working with you.

May we bid a fond farewell to 2021 and look forward to an even better 2022!

Audrey P. Kearns
Editor

* Based on laboratory measurements in an approximately 1,000 cubic ft. (SFT3) space with ducted return at pressure difference of 0.020 (in WC). Actual results and savings may vary based on specific room configuration (size, configuration, MEP, pressure, etc.).

Cleanroom Airflow Measurement Certainty



By Matt Lemieux

This article examines the benefit of statistical forensics on cleanroom certification reports. Two certification efforts were conducted in successive years on the same client facility performed by two certification efforts. Airflow CFM was examined for ceiling mounted terminal hepas whereby both total capture flowhood readings and air velocity readings were taken.

We were contacted by a medical device client to assume the cleanroom certification responsibilities previously being conducted.

The client's cleanroom facility consists of 98 ceiling hepa filters of type A, disposable, ducted supply, serviced by two rooftop air handling units. The facility airflow was also supplemented by a handful of recirculating fan filters, Type B, to achieve design air exchanges. This discussion concerns only the Type A hepa filters.

As is often the case, some of the hepa filters were inaccessible by a total capture flow hood due to process equipment obstruction. Of the 98 Type-A hepa filters, 88 were flow hood accessible. The client presented our testing group with the previous certification test report which included reflected ceiling drawings, hepa filter locations, hepa filter identification numbers and the most recent certification data. In the interest of consistency, our group would plan to adhere to the hepa filter identification scheme.

The owner provided airflow data indicated with a footnote which 10 of the 98 filters were measured with a velocity instrument and, consequently, had their volumetric flow calculated (A_k method), rather than being directly captured with the flow hood. The measured velocities were not explicitly stated, nor were the value(s) for corresponding area, A_k given.

This facility was particularly well designed, balanced, and maintained with regard to airflow. The client maintenance personnel and primary mechanical contractor were on-site during the off-hours testing effort to assist in remedying any shortcomings in real-time. The hepa filters all had very healthy airflow with an average of 630 CFM and a relative standard deviation of just over 15%, with no anemic hepa filters.

After we completed the airflow measurement effort consisting of direct capture, backpressure-compensated flow hood measurements and corresponding airflow velocities with a multi-point pitot array grid at 6″ from the filter face, we compared the 'as-found' readings with the results provided by the owner. The values were very similar, with an average CFM of 651 (in contrast with the 630 CFM also backpressure-compensated). The difference in the average velocities and flows was less than 4%. We used a multipoint pitot array grid on the same ten filters that had been used because of the equipment obstructions. The A_k value was determined as the average of 24 accessible filters with contemporaneous backpressure-corrected flowhood readings and multipoint pitot array velocity readings.

Equations 1 and 2 below describe the proper application of the velocity method for determining airflow CFM which we utilized.

Stock image.

EQ.1:

$$Q_{meas} = V_{meas} * A_k$$

EQ.2:

$$Q_{meas} = A_{meas} * V_{meas} * K_v$$

Where:

- **Q_{meas} - measured volumetric airflow with capture flow hood (ft3/min)**
- **V_{meas} - Air velocity measured with multipoint pitot grid at a prescribed distance (ft/min)**
- **A_{meas} - Area of exposed filter media measured with a tape measure (ft^2)**
- **A_k - the corrected exposed filter area which reconciles Q_{meas} with V_{meas}.**
- **K_v - the velocity correction, which reconciles Q_{meas} with A_{meas}.**
- **A_k - can be expressed as the product of V_{meas} and K_v.**

In evaluating the data, a particular phenomenon in the previous results was noted whereby the ten obstructed hepa filters appeared to have, higher CFM readings than the other 88 filters. The previous obstructed filter measurements averaged 760 CFM in contrast to the unobstructed filters, which averaged 615 CFM. The present testing group determined an average of 661 CFM on the obstructed filters and 651 CFM on the unobstructed hepa filters. Since the placement of the process equipment within the facility had no correlation with the air balancing results, an obstructed hepa filter has an equal likelihood of delivering less-than-average airflow as it does deliver higher-than-average airflow.

Was this apparent higher airflow phenomenon imaginary, illusory, or simply coincidental? Is it possible to determine, statistically, whether the obstructed filters and, therefore the method used to measure them, was significantly different?

Table 1 shows the calculated CFM for the 10 obstructed filters from the report:

Table 1: Previous Calculated CFM	
FILTER I.D.	CFM (A)
19	948
53	781
56	825
57	722
59	580
66	688
67	802
76	705
77	833
79	719

Table 2 shows the summary statistics for both the previous data and the present data calculating all 98 ducted supply filters, the 88 flowhood accessible and the 10 obstructed hepas.

A two-sample, student's T, difference-of-means test was conducted on the two data sets, the previous, and the present test results.

Figure 1 shows the results of that statistical test:

Figure 1: Student's t-test, difference of means

	PREVIOUS	PRESENT
t-test	***4.83***	***0.53***

Under the previous methodology, the t-test result of 4.83 indicates a >99.995 statistical significance that the set of 10 readings came from a different population, i.e., the test and calculation methodology was definitely in error. In contrast, the t-test done on our data (0.53) shows no statistical significance between direct capture flow hood readings and velocity-calculated CFM readings.

Table 3 contrasts the two results on the 10 obstructed hepa filters.

Table 2: Airflow Statistics

	PREVIOUS			PRESENT		
n	98	98	10	98	88	10
AVERAGE	630	615	760	651	651	661
ST DEV	99.8	88.8	100.5	102.3	100.1	111.8
RSD	15.8%	14.4%	13.2%	15.7%	15.4%	16.9%
MIN	465	465	580	449	449	504
MAX	948	925	948	863	863	834
RANGE	483	460	368	414	414	330

Table 3: Calculated Airflow CFM		
FILTER I.D.	**CFM Calculated (Previous)**	**CFM Calculated (Present)**
19	948	834
53	781	624
56	825	504
57	722	660
59	580	580
66	688	578
67	802	570
76	705	598
77	833	836
79	719	800

Figure 2 shows the frequency distribution of all 98 hepas.

Figure 3 shows the frequency distribution of all 98 hepas for our results for both the flow hood-measured hepas and velocity-calculated (A_K) hepas.

In figure 2, it can be seen that 90% of all the velocity-calculated readings were above the average CFM of all filters. In fact, 90% of the calculated CFM's were higher than 83% of their flow hood measured CFM's. In figure 3, 50% of the velocity-calculated readings were below average and the other 50% above average, as would be expected if a valid CFM calculation method were used.

This analysis demonstrates that, for airflow CFM, when it is necessary to calculate the volumetric flow from measured average velocity and measured area, using the NEBB CPT protocol detailed in equation 2 results in statistically significant data. The difference-of-means method of statistical analysis is a useful and even in-

Figure 2: Previous Frequency Distribution

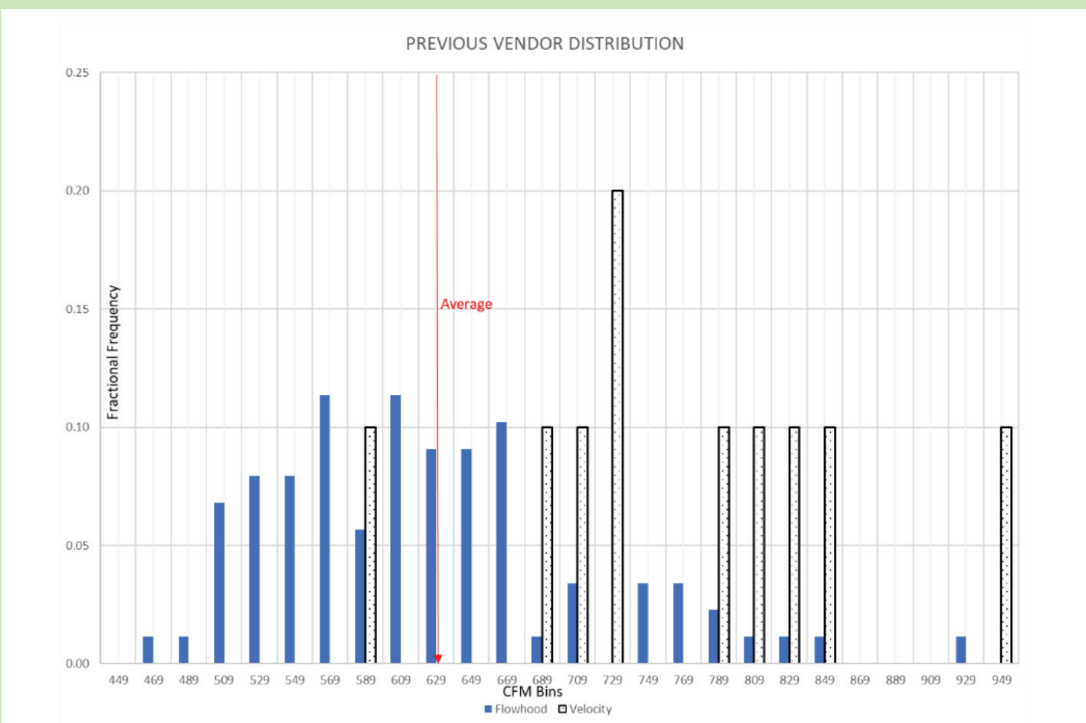
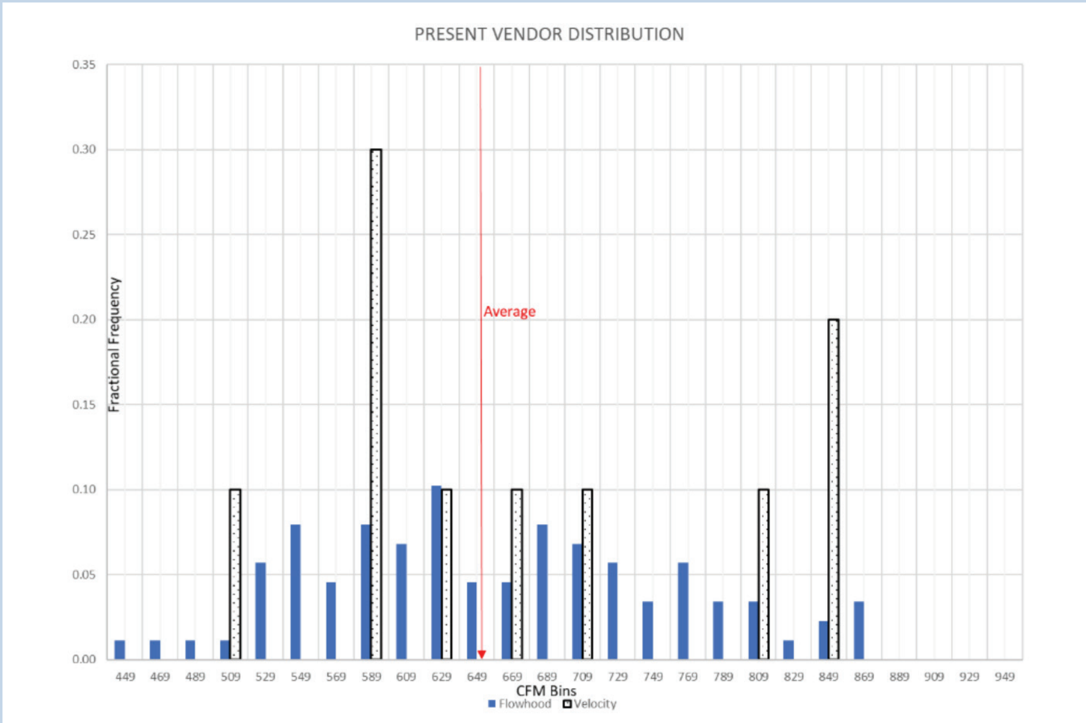


Figure 3: Present Frequency Distribution



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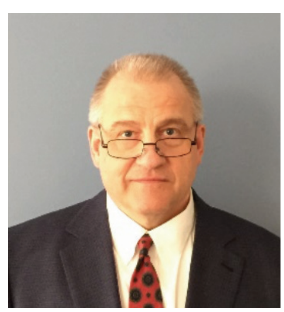
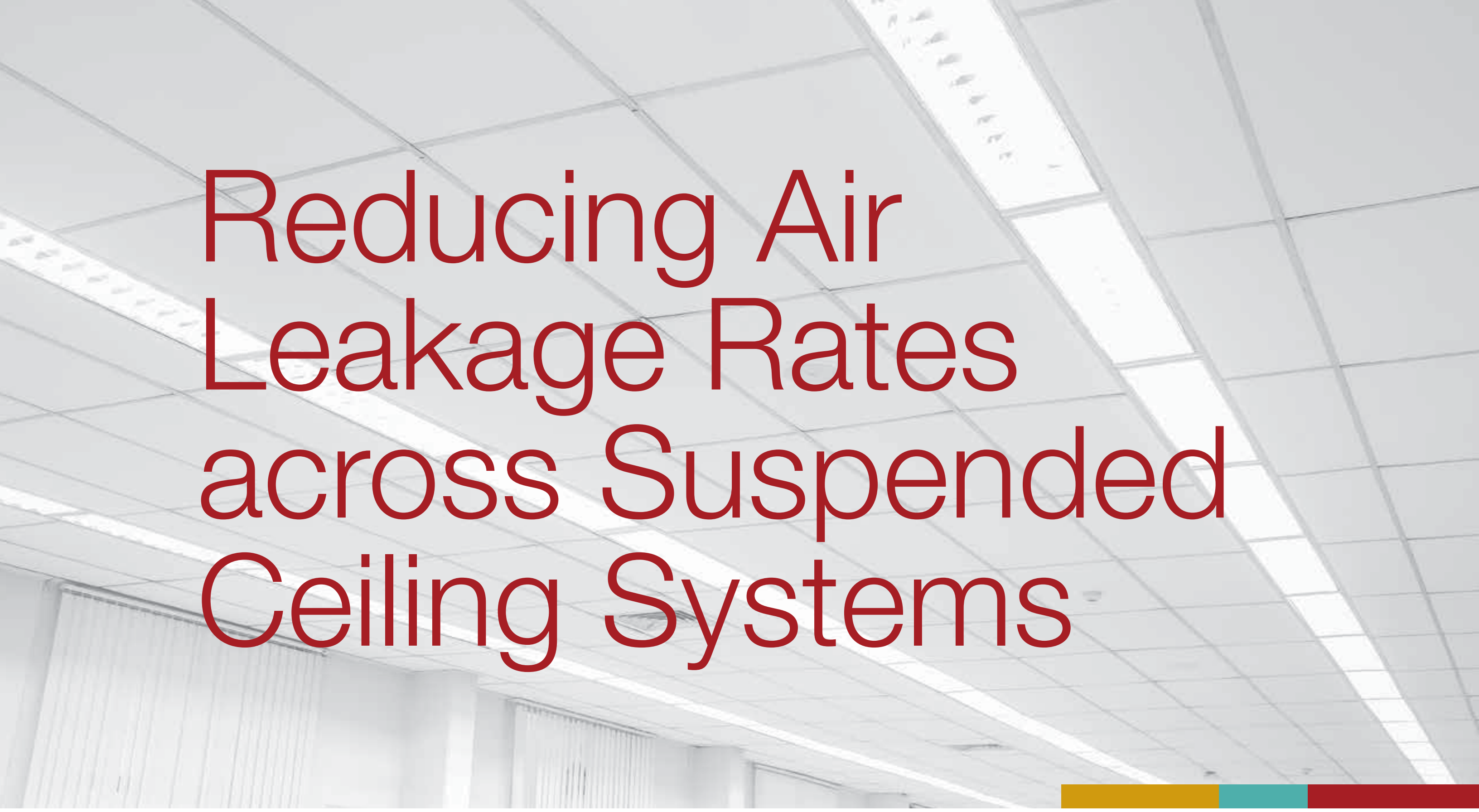
dispensable tool for revealing contradictory methodology. This is especially important where detailed procedural disclosure is lacking, and incomplete test data was provided. Statistical methods can indeed be used forensically to evaluate cleanroom test reports as this study shows. ●

About the Author:



Mr. Lemieux (E.I.T.) has 39 years' experience in the cleanroom industry, a B.S. in mechanical engineering, associate degree in electronics engineering, and has been an ANSI/NSF-49 accredited biological safety cabinet certifier since 1997. He is a NEBB CPT-CP certified professional as well as a CETA accredited RCCP-SCF for sterile compounding facilities, cleanroom testing and ASHRAE 110 fume hood testing.



Reducing Air Leakage Rates across Suspended Ceiling Systems

Introduction/Background

Room Pressure to Control the Flow of Air and Contaminants

Pressure differences between spaces in a building are commonly used to control the flow of air and possible containments away from clean spaces and toward less clean spaces by way of cascading pressurization. Wei Sun [1] states that "room pressurization or depressurization is normally used to achieve desired airflow directions and to minimize airborne particle, biological, gas and/or chemical contamination from a less-clean or contaminated room into a cleaner or protected room. In this approach, air pressure differentials are created mechanically between rooms to introduce the intended air movement through room leakage openings."

Traditional Applications and Emerging Applications

James Coogan [2] notes that this method of contamination control is used in areas such as hospital isolation rooms, hospital pharmacies, and clean manufacturing applications. In addition to these "traditional" applications, he also notes some "non-traditional" usages such as smoke control in office towers during a fire event, separating restrooms from other parts of a building, managing kitchen odors and smoke in restaurants, and any building where it's important to keep unconditioned outside air out of occupied spaces. Pressure differences and controlled leakage are also important in Hot Aisle Containment (HAC) style data halls (energy savings) and manufacturing control rooms (dust and fume control). Andy Persily [3] points out that mail rooms, loading docks, and public lobbies are also areas where controlled leakage is beneficial, particularly regarding Chemical Biological Radiological and Nuclear (CBRN) threats.

New Considerations, Pandemics, Extreme Climate Events

More recently, Wei Sun [1] states that "during the COVID-19 pandemic, it has become urgently important to design, operate and retrofit buildings correctly to minimize or prevent airborne pathogen transmissions between rooms. Recent guidance from ASHRAE [4] indicate that health suites in K-12 schools should be configured to operate as cascading, pressure-controlled spaces with a flow direction from corridors to the health suite lobby, and into individual sick rooms to be then exhausted to the exterior.

Tim Roaten explains, in early 2020, resident rooms in both independent and assisted living facilities were being retrofitted to create negative pressure spaces [5]. The creation of negative pressure spaces was designed to both isolate residents who had been diagnosed with COVID-19 and to aid in reducing transmission of the virus throughout the facilities, many of which are connected by shared or common spaces. Negative pressure spaces were created by using portable HEPA filter fan units. While in most instances, the capacity of the portable HEPA filter fan units should have been sufficient to create the desired pressure differential, the greatest challenge was the integrity, or lack thereof of the room and building envelope. Senior Living facilities are constructed for aesthetics and resident comfort, not pressure control. In many cases to achieve the desired differential pressure relationships, temporary walls were added to corridors and the existing acoustical ceiling tiles were caulked in place in the ceiling grid system [7].

The need to consider pressurization in non-traditional applications is driven not only by urgent health crises like pandemics, but also by extreme climatic events such as smoke from wildfires, decaying detritus from hurricanes, and poor AQI days in our urban areas. Mindi Young points out that, during historic west coast wildfires, proper cascading pressure control and controlled leakage between interior spaces was critical to maintaining indoor air quality in an advanced manufacturing facility. These same extreme events also impact non-manufacturing facilities. It's likely that design strategies and techniques will carry over to these non-traditional applications.

Enclosure Tightness and Suspended Ceiling Systems

Many experts acknowledge the important role that the air leakage characteristics of an enclosure plays in determining net airflows for pressurization. Andy Persily [3] states "success requires that the envelope is sufficiently tight and that the net airflow into the building is large enough to overcome the pressures created by outdoor weather conditions. The amount of airflow required is directly related to the building envelope leakage—the leakier the envelope, the more airflow is needed."

Wei Sun [1] points to this "to reach the same pressure differential, it is more cost-effective to make a room tighter (by better sealing) which requires a smaller offset between incoming (supply) and leaving (return or exhaust) airflows, than a looser room which requires a larger offset... and makes the task of HVAC design and air balance more complicated."

Air leakage between spaces in buildings is gaining more attention. When the technology is implemented in more "non-traditional" applications, it will be critical to do it right and do it in an energy efficient way. The industry is going to need more knowledge about leakage characteristics of interior enclosures, including partition walls, doors, lights, fire protection systems, and suspended ceiling systems.

About the Authors

(Alphabetical by last name)

Bill Frantz *is a senior principal scientist and engineer in the Innovation Group of Armstrong World Industries in Lancaster, PA, USA. He leads exploratory efforts to develop new building products for the company. He is a member of ASME, ASHRAE and TC9.11 Clean Spaces.*

Tim Roaten *is president of Eastern Air Balance in Manheim, PA. He has over 30 years of service as a TAB and commissioning professional. He is a NEBB Certified Professional.*

Wei Sun*, P.E., is president of Engsysco with offices in Ann Arbor and Farmington Hills, Michigan. He is an ASHRAE Distinguished Lecturer, a member of Technology Council, past Chairs of Environmental Health Committee and TC 9.11, Clean Spaces. He was past IEST Society President and serves as NEBB's CPT Standard Chair and ISO TC209 Standards U.S. Delegate.*

Mindi Young *is vice president of business development at VanirTG in Portland, OR. She has 19 years of industry experience specializing in Cleanroom Performance and Critical Environment Testing. She is a NEBB Cleanroom Performance Testing Certified Professional.*

Laboratory Testing of Suspended Ceilings and Components

Motivation

Air within an interior space can leave that space by many different parallel paths. In addition to planned paths such as return air and transfer grills, doors, electrical outlets, wall penetrations, light switches, light fixtures, fire protection sprinklers, and ceiling mounted sensors all represent potential fugitive leak paths. Suspended ceilings frequently form the "top of the box" in a room and are often overlooked as leak points or wrongly dismissed as impractical to make tight.

Armstrong first became interested in quantifying leakage rates across perforated metal ceiling planes in 2001. At that time, the context was related to fire sprinkler performance and how flow through perforated panels could influence the reaction times for sprinklers. Soon after in 2002, Armstrong leveraged what we learned to explore a novel "ceiling supply plenum" approach to air distribution. Later, in 2012, the company extended low leakage suspended ceiling systems to control leak points and save operating energy in Hot Aisle Containment (HAC) data halls.

In early 2020, at the on-set on the COVID-19 pandemic, Armstrong anticipated that pressurization could be an important way to manage potential contaminant flow. We saw that retrofit of existing spaces into pressure-controlled spaces could be a critical need. We re-started work on low leakage rate suspended ceiling systems.

Small-scale Test Apparatus

Supporting all this work is a small-scale test apparatus based on ASTM E-283 "Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, And Doors Under Specified Pressure Differences Across the Specimen" [6]. Although not specifically written for suspended ceilings, we saw it as a practical and fundamentally sound approach for our testing.

The test apparatus consists of a 48 x 48 [in] chamber that is 12 [in] deep (Fig. 1). The chamber is well sealed on five sides against air leakage. Samples are mounted in removable frames that clamp and seal tightly like a lid onto the top of the box. Air is introduced into the test box via compressed air or by metering pressure blower. Flowrate is measured via rotameter or calibrated orifice plate (Fig. 2). The ceiling assembly is sealed in a test frame so that air must flow through the sample from one side to the other (Fig. 3). The pressure difference across the sample is measured via micromanometer. Airflow through the sample is measured and resulting pressure differences across the test sample are recorded. Typical "power law" equations are used to fit the data and characterize the flow resistance.

1

2

Figure 1. Test fixture. Nominal 4 x 4 [ft] frame with grid and molding holds the ceiling panels under test. Metered air is introduced in the bottom of the box and passes through the assembly.

Figure 2. Airflow meters and manometer. Rotameters measure airflow [cfm]. Manometer measures pressure difference [in WC].

Figure 3. Typical suspended ceiling tiles mounted in test frame.

3

If the sample is a grid and tile assembly, then airflow is normalized by the area of the assembly. If the sample is a single item, such as a fire sprinkler, lay-in light fixture, high hat light fixture or other penetration, the sample tray is sealed so that all air must pass through/around the item under test (Figs. 4, 5, 6, 7, 8, 9). Leakage rate [cfm/ft2] is determined across pressure differences ranging from 0.000 to 0.090 [in WC].

Leakage Rates in Suspended Ceilings

Measured leakage rates will vary depending on pressure difference across the ceiling plane, direction of the pressure difference (positive or negative), type of ceiling panel (permeability), weight of tile, type of edge and the use of hold-down clips. The plot below (Fig. 10) shows a typical test result for an AirAssure mineral fiber ceiling tile with special soft gasketing on the perimeter of the tile.

Figure 4. Typical suspended ceiling tiles in test frame.

Figure 5. Leak test of a grid installed air cleaner.

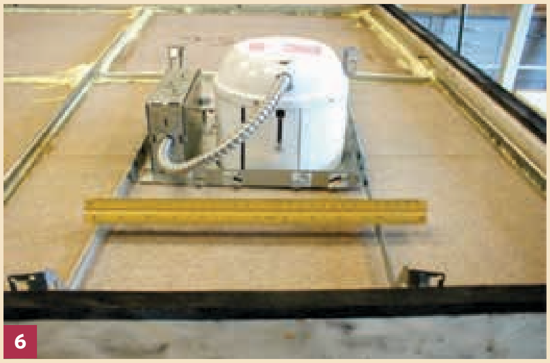


Figure 6. Leak test on a high hat light fixture.

Figure 7. Leak test on a 2x2 [ft] lay-in troffer light fixture.

Figure 8. Simulated penetration of a fire sprinkler pipe.

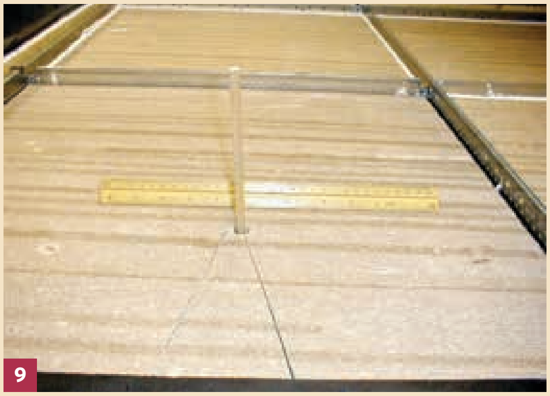


Figure 9. Simulated penetration of a cable tray drop rod.

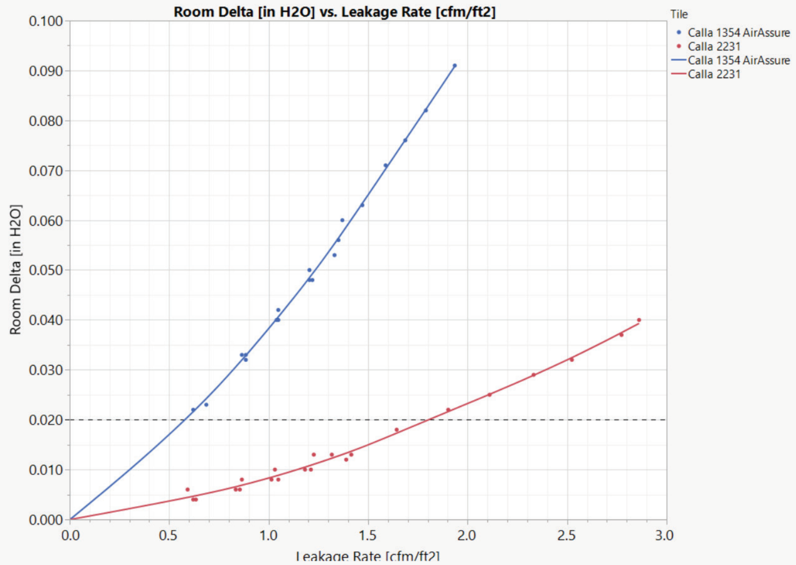


Figure 10. Typical test result from a leakage rate test. A typical mineral fiber tile has a leakage curve (red) and may leak at a rate of about 1.75 [cfm/ft2] at 0.020 [in WC]. The addition of a special soft gasket reduces that leakage rate to about 0.60 [cfm/ft2].

Pressurization and De-pressurization of Test Rooms

Suspended ceilings frequently form the "top of the box" in a room. To pressurize a room for contaminant control, one must supply excess air (for positive pressure) or exhaust excess air (for negative pressure). The net airflow required depends on leaks in to or out of the space. When leaks are reduced, the enclosure's airtightness is better, the amount of air required to either pressurize or depressurize is also reduced. This results in a reduced energy to move the air and better control of resulting pressure differences.

Factors Modifying Performance

Spring clips or "hold-down clips" can be used to press the gasketed tile more firmly onto the grid. The use of clips improves the seal significantly. In the case of positive pressure rooms, clips reduce the tendency for tiles to lift off the grid. Clips are recommended for positive pressure rooms when the pressure difference across the ceiling system is expected to approach about 0.090 [in WC]. Pressures above this level start to equal the weight of the tile and can cause the tile to lift from the grid.

Suspended ceiling tiles are frequently cut to fit the perimeter of a room. When the best possible seal is required, it is recommended to apply gasketed to the tile at the cut edges and seal the gap between the wall and the perimeter molding of the ceiling.

Pressurization and De-pressurization Room Tests

To demonstrate the impact of low leakage rate ceilings on pressure-controlled spaces, a laboratory test was conducted. A test room of 10 x 12 [ft] in size had air supplied by a pressure blower and exhausted by a reverse flow fan filter unit (Fig. 11). The net air flow in-out could be con-

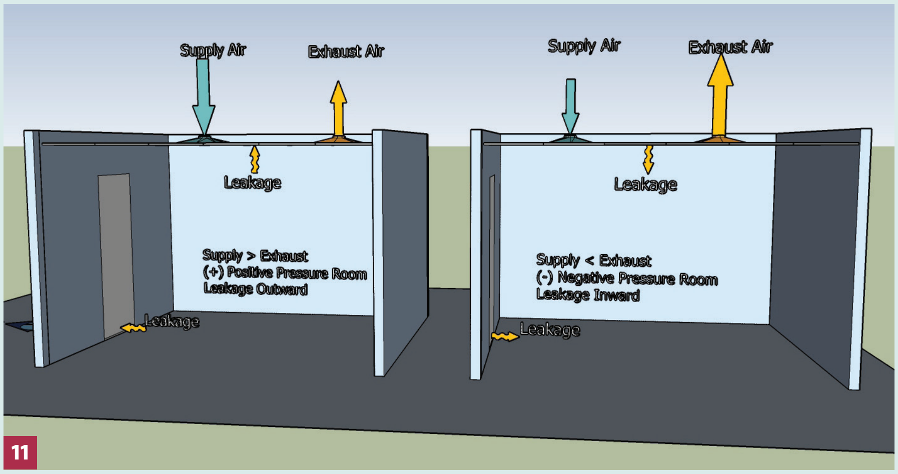


Figure 11. Left, airflow supply into room is greater than exhaust flow, creates "positive pressure room" relative to surroundings, controlled leakage is out of the room. Right, airflow supply into room is less than exhaust flow, creates "negative pressure room" relative to surroundings, controlled leakage is into the room.

trolled. Resulting net flow rates and room pressures were measured. The test was repeated for a standard ceiling system and an AirAssure low leakage rate ceiling system.

This simple test clearly shows the benefit of controlling leakage through the ceiling plane (Figs. 12, 13). De-pressurizing to -0.020 [in WC] required an exhaust flow of 150 [cfm] with a conventional system. Achieving the same pressure result with a low leakage ceiling system required an exhaust flow of only 90 [cfm]. This 40% reduction in airflow translates to a 78% reduction in fan power.

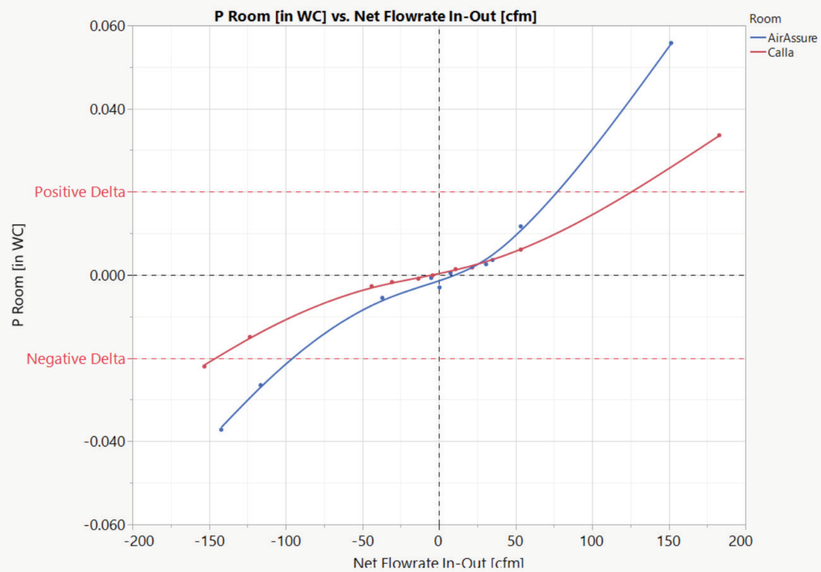


Figure 12. Room pressurization with varying net airflow rates into the room. AirAssure ceilings reduce fugitive leakage, allowing you to achieve a design pressure difference with less net airflow and fan energy. Note that these results are specific to the test room size and the background leakage rate of the enclosure.

Practical Applications

The effect of low leakage suspended ceilings was recognized in two practical installations.

Improved Pressure Control in an Airborne Infection Isolation Room

Encompass Health Rehabilitation Hospital located in Middletown, Delaware is a medical inpatient rehabilitation facility, designed to help patients recover from stroke and other complex neurological and orthopedic conditions. The facility includes one Airborne Infection Isolation Rooms (AIIR) (Fig. 14). The Airborne Infection Isolation Room is designed / required to operate at a pressure of -0.020 [in WC] with respect to the adjacent corridor. Over the course of the past several years, the room has experienced frequent low pressure nuisance

Table 1. Net airflow to achieve a target pressurization. AirAssure™ requires less airflow to achieve the same pressurization.

Ceiling Type	Net Airflow Required for +0.020 [in WC]* Positive Pressure Room	Net Airflow Required for -0.020 [in WC]* Negative Pressure Room
Calla®	125 [cfm] excess supply	150 [cfm] excess exhaust
AirAssure™	75 [cfm] excess supply	90 [cfm] excess exhaust
Percent Reduction with AirAssure	40 [%] less	40 [%] less

Figure 13. Negative pressure patient room at Encompass Healthcare.

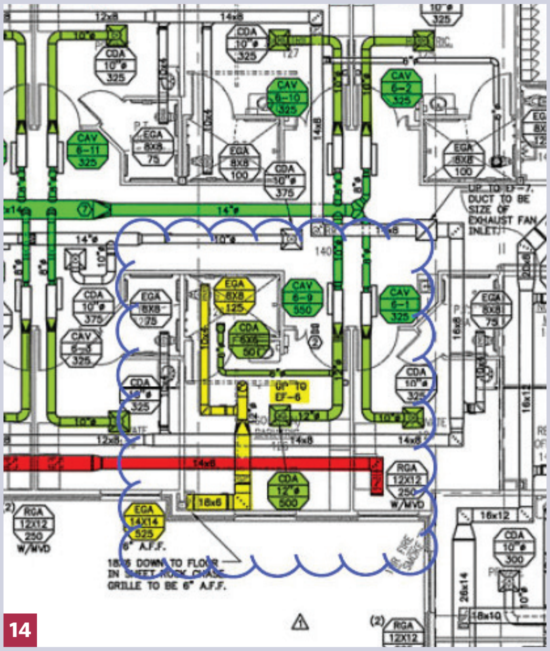


Figure 14. Patient room detail.

alarms, which could distract medical staff from other duties. The dedicated exhaust fan system serving this room was operating at its maximum capacity, and the room could only achieve and sustain a differential pressure of -0.0189 [in WC] with relationship to the corridor. Rather than replace the existing exhaust fan, the conventional suspended ceiling was replaced with a low leakage rate ceiling (Fig. 13). The introduction of the low leakage ceiling tightened the enclosure enough to change the actual room differential pressure to -0.0368 [in WC] without increasing the exhaust airflow rate, and eliminated the nuisance alarms.

Pressurization to Improve Air Quality in a Manufacturing Break Room

Armstrong World Industries operates a mineral fiber ceiling tile manufacturing plant in Macon, GA. As part of a facilities upgrade, there was a desire to change the 890 [ft2] central break room into a positive pressure space (Figs. 15, 16). This was expected to keep nuisance dust out of the break room and provide a clean, comfortable place to eat and relax between shifts. Prior to the renovation, the break room operated at -0.015 [in WC] pressure with a net flow inward from the manufacturing plant into the room. The conventional suspended ceiling was replaced, and sufficient excess supply air was supplied to the space to create a +0.021 [in WC] pressure relative to the manufacturing plant. This created an outward flow of air and significantly reduced the particulate in the break room. The low leakage ceiling system only required 650 [cfm] excess supply air to achieve the target pressure. If a conventional ceiling was used, it is estimated that 1250 [cfm] excess supply air would have been necessary.

Room conditions were monitored with Awair Omni IEQ sensors before and after the changes were implemented. Before the changes, the room operated at a negative pressure of -0.015 [in WC] and airflow was clearly from the manufacturing plant into the break room. After the changes, the room operated at positive +0.021 [in WC] and excess airflow was outward from the (clean) breakroom to

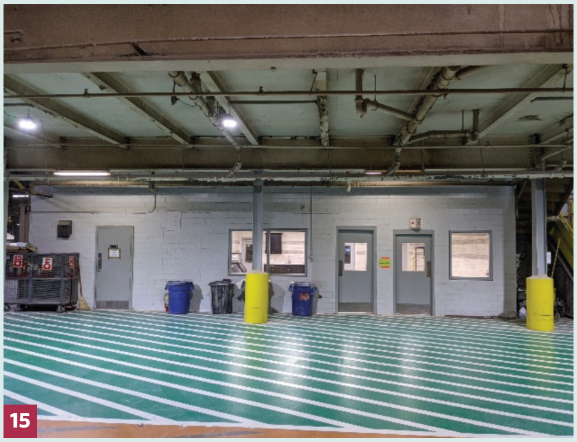
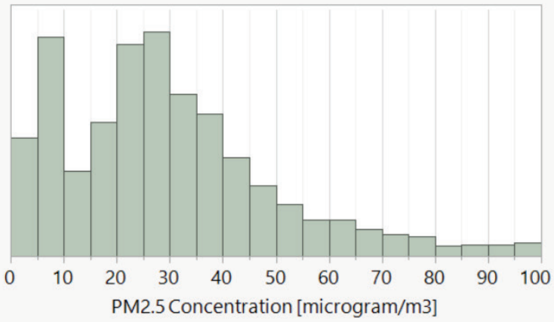


Figure 15. Exterior view of the break room.

Figure 16. Interior view of the 890 [ft2] break room. Low leakage rate ceiling system and +650 [cfm] excess air created a +0.021 [in WC] positive pressure space relative to the manufacturing plant. Nuisance dust and hot/humid air from the plant cannot enter the space.

Distributions Room Status=Before

PM2.5 [microgram/m3]

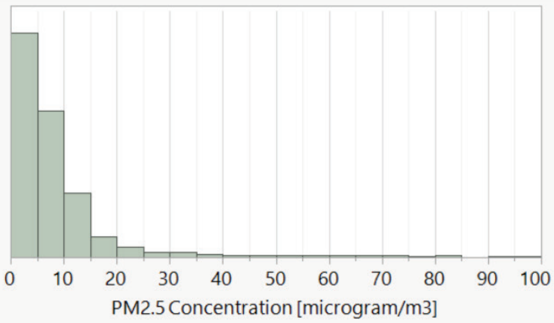


Quantiles		
100.0%	maximum	1000
99.5%		1000
97.5%		503.625
90.0%		86.9
75.0%	quartile	44.1
50.0%	median	28.4
25.0%	quartile	16.8
10.0%		6.2
2.5%		3.375
0.5%		2.3
0.0%	minimum	1.9

Summary Statistics	
Mean	60.5
Std Dev	137.8
Std Err Mean	2.7
Upper 95% Mean	65.8
Lower 95% Mean	55.1
N	2589.0

Distributions Room Status=After

PM2.5 [microgram/m3]



Quantiles		
100.0%	maximum	975.9
99.5%		221.972
97.5%		39.9325
90.0%		15.5
75.0%	quartile	9.7
50.0%	median	5.55
25.0%	quartile	3
10.0%		2.1
2.5%		1.6
0.5%		1.3
0.0%	minimum	1.1

Summary Statistics	
Mean	10.8
Std Dev	36.6
Std Err Mean	0.7
Upper 95% Mean	12.1
Lower 95% Mean	9.4
N	2700.0

Figure 17. Top chart: PM2.5 concentration before the room was pressurized ranged from 6 to 87 [micrograms/m3]. After the room was pressurized, the PM2.5 count reduced to 2 to 16 [micrograms/m3].

the (less clean) manufacturing plant. The reduction in particulate concentrations were remarkable (Fig. 17).

Conclusions

Pressurization and de-pressurization of spaces is a well-known means of controlling airflow and the possible transfer of contaminants. It's commonly applied in critical environments such as hospital isolation rooms, hospital pharmacies, and clean manufacturing applications. The industry may be at a point where "typical buildings" may need to adopt some of the design techniques to respond to urgent health crises such as pandemics and extreme climatic events. Greater attention to enclosure leakage and surfaces like suspended ceilings may be necessary to achieve design goals. The ability to economically retrofit existing spaces into pressurized spaces may become important. Furthermore, it may become more common to require a space to easily "toggle" between a normal mode of operation and a critical event mode of operation. ●

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ASHRAE 170 COMPLIANCE

Ventilation of Health Care Facilities | Real-world Challenges Observed by a Commissioning Provider

By Tyler Hall | NEBB YPN

INTRODUCTION

Space pressure relationships, air exchanges, relative humidity, and temperatures all play a vital role in healthcare facilities' daily operations. Considering healthcare-associated infection rates and the global pandemic (COVID-19), healthcare facilities' environmental conditions are more relevant today than ever.

ANSI/ASHRAE/ASHE Standard 170, Ventilation of Healthcare Facilities, defines design requirements for environmental control, but who is responsible for verifying the systems are compliant prior to construction, before occupancy, and throughout the life of the systems? This paper will tackle real-world challenges facing ASHRAE 170 compliance from a commissioning provider's perspective.

DESIGN CHALLENGES

During the design phase, the number one challenge, which almost always leads to compliance issues down the road, is the lack of specifying testing requirements. Unless the contract documents specifically require verification of ASHRAE 170 compliance, it becomes a toss-up whether the actual performance is adequate for the spaces' function.

But what about the Testing, Adjusting, and Balancing (TAB) firm? Aren't they contracted to balance the systems to the design? Balancing the mechanical systems within the allowable tolerances and ASHRAE 170 compliance verification are entirely separate tasks. Most reputable TAB firms are undoubtedly capable of both tasks, but the latter will not occur unless specifically required in the contract documents. Simply put, no services are free, and

in a competitive market, competitive pricing is invaluable. To receive a quote, the quote must first be requested.

Furthermore, systems being in tolerance with the design does not mean the spaces are compliant with ASHRAE 170 requirements. What if that -10% tolerance puts the system below the required air exchanges per hour (ACH), or the designed 100 CFM supply/exhaust air offset is not enough to maintain the necessary pressure relationship?

So, who is responsible for compliance verification? Per many contract documents, no one is required to verify compliance, and the hospital inherits latent design or construction issues. To make matters worse, the patients also inherit these issues. Ventilation issues are often identified as the hospital preps for accreditation or during the accreditation process itself, which sometimes close to the end or after the project's warranty period – leaving the owner little recourse. Also, no inspection process is perfect, and it is not uncommon for ventilation issues to go unresolved for years.

When spaces have pressure relationship requirements, a whole new set of challenges apply. Not only does the mechanical design need to account for pressure relationships, but the architectural design must be factored in too. Commonly, the designed airflow pressurization offset cannot overcome leakage through the space's envelope, leading to insufficient pressurization at the main entryways. Addressing pressurization issues during construction (usually a few weeks before turnover) can be tricky. Replacing or modifying mechanical equipment is challenging at best or practically impossible at worst, but sealing wall penetrations and installing door gaskets is comparatively easy. However, if not already designed, costly change orders and project delays ensue.

Another challenge facing ASHRAE 170 compliance is room naming conventions. It is quite common for room names to be different from the "Function of Space" listed in the ASHRAE standard. For example, suppose a gastrointestinal endoscopy procedure room is named "procedure room." In that case, it will not be clear what the function of the space is, as there are different requirements for endoscopy procedure rooms and rooms intended for other surgical procedures. Furthermore, if the endoscopy procedure room is additionally used for bronchoscopy procedures, then additional requirements are applicable in that case too. Though simple, naming conventions matter.

Just because an operating room requires a minimum of 20 ACH does not mean the room should be designed for precisely 20 ACH. Similar to heating load calculations, a buffer is needed to compensate for different variables and unknowns. Likewise, this buffer needs to leave room for field adjustments and system tuning. In more cases than not, field tuning is required to bring spaces in tolerance with ASHRAE 170 standards, especially when it comes to pressure relationships.

CONSTRUCTION CHALLENGES

During construction, the question is not, "will issues be encountered?", but rather, "when will the issues be encountered?". Deficiencies during compliance verification are inevitable. Success depends on upfront planning, quality control, and the allotted timeframe to address problems. If the project's schedule is compressed, the quality control suffers. Likewise, compliance verification suffers due to a lack of quality control. Furthermore, if compliance verification is occurring the day before occupancy, resolving problems encountered is unlikely.

TESTING CHALLENGES

In the event the contract documents require ASHRAE 170 compliance verification, or the hospital contracts a testing agency, numerous challenges can be encountered. While not an exhaustive list, the following are examples of real-world observations.

As a commissioning provider, we have observed spaces compliant after construction but fail a few short months later. Compliance longevity of critical hospital spaces is dependent on many factors. A common source of failure is seasonally based. If testing occurred during mild ambient conditions during the spring or fall seasons, temperature and humidity ranges might not be adequate during peak winter or summer loads. If an operating room were tested during the humid summer months, humidification control likely could not be fully proven before turnover. During dry transitional periods, especially during full economizer (100% OA), often

humidity control issues are quickly identified by surgical staff. For spaces that require positive pressurization, minimum airflow scenarios are favorable, as the air handlings unit's total return airflow is lower across the system. Suppose a clean holding room with a constant volume supply airflow setpoint was compliant during the winter season's peak. During the summer season, pressurization may become problematic as the total return airflow has increased, decreasing the supply/return airflow offset within the clean holding room.

It is essential to understand the worst-case scenario and what state the adjacent spaces are in after occupancy. Pressure relationships can be tricky. If testing focuses solely on the room tested, unforeseen compliance issues may arise down the road. For example, does the adjacent corridor door affect the pressurization of the tested space? During occupancy, is said door ordinarily open or normally closed?

Furthermore, what state is the VAV system in – maximum airflow, minimum airflow, or somewhere in between? Or how about that extensive exhaust air system that is off due to a VFD fault? Even if the space itself is constant volume, the surrounding systems make an enormous difference.

Another challenge we all face is human error. Often due to a lack of attention to detail. Mistakes made while measuring room volume, forgetting to check both the total and outdoor ACH, taking pressure measurements at the corridor but not the adjacent spaces, and not verifying the filtration type are all real examples of compliance issues. On the surface, it may seem like the room "passed," but if adequate time is not allocated to review all aspects of compliance, you are setting yourself and the customer up for failure. Taking the time to understand ASHRAE 170 standards and reading all the notes and the addendums is crucial.

Many hospital rooms merely require negative or positive pressurization, with no numerical pass/fail criteria provided. It is far too common to see tested rooms "pass" when the measured pressure is 0.0001 In. w.g. (essentially neutral), or when the measured ACH is precisely the minimum required amount. As aforementioned, a buffer is needed to account for instrumentation accuracy, as well as fluctuations inherent to mechanical systems. In addition to bringing spaces in compliance with the standards, system longevity should be a goal too.

Hospitals often consist of many renovations and additions, and the time between these renovations and additions can be decades. ASHRAE-170 is incorporated into the FGI guidelines (the basis of hospital design and construction). It is essential to know which version of the FGI guidelines and subsequent ASHRAE 170 standards are applicable when testing existing hospital spaces. If ASHRAE 170-2017 applies to a renovation project, but ASHRAE 170-2008 is being used to determine pass/fail criteria, inherently compliance issues will arise, and the same is true vice versa.

SOLUTIONS?

TRUST BUT VERIFY | Traditional TAB services are not enough. Verification of ASHRAE 170 compliance should always be performed regardless of the contract documents. Much like Building Systems Commissioning, it is invaluable to both the owner and the construction team – at the end of the day, all parties know the job was done right.

There are two common approaches to fill the void between TAB and ASHRAE 170 compliance verification. First, the owner can contract a third-party firm directly. As a technical commissioning provider, we identified a gap leading to deficiencies post-warranty phase and began providing compliance verification as a commissioning service. If process-based commissioning is provided, identify the void during the design phase. Even better, help the owner develop Owner Project Requirements (OPR), so testing obligations are integrated into the contract documents.

PRESSURIZATION | Designing pressure relationships of spaces is not an exact science. Nine times out of ten, field tuning will be required and is often outside of the +/-10% design tolerances. A step in the right direction would be first to identify the pressure critical spaces and then collaborate with the architect to ensure the room envelope is also designed to accommodate the needed differential pressure. Similarly, the commissioning firm or testing agency should review the architectural and mechanical design to gauge the likelihood of maintaining the pressure requirements. If a space is designed for a 30 CFM pressurization offset, has a suspended ceiling, no requirements for sealing wall penetrations, and no door gaskets or sweeps, it is a safe bet the pressurization will not be adequate. The goal here is to collaborate to identify and correct issues as early as possible before becoming time-consuming and costly.

DELETING THE GUESSWORK | When developing our testing plans, every project has at least one vaguely named room such as "storage 1-101." The subsequent RFI goes something like this: "What is the function of the room… clean linen storage, janitor's closet, soiled storage, hazardous material storage?"

Using descriptive room naming conventions is a positive step forward. The room name should incorporate language like ASHRAE 170's "Function of Space." The most successful idea implemented to date has been requiring design schedules structured like the tables included in ASHRAE 170, listing all the critical spaces' ventilation and pressure requirements.

The testing agency must know which version of the FGI guidelines and subsequent ASHRAE 170 standards are applicable for existing hospital spaces. As-built drawings need to reference the date of the FGI guidelines. Likewise, testing forms should also reference where the pass/fail criterion is coming from. In addition to dozens of decade-old design drawings, having a consolidated list of all the critical spaces that require compliance verification goes a long way. The comprehensive list should include the function of the space, room name, FGI/ASHRAE version, the renovation date along with the project name. Bonus points if the pass/fail criterion is also listed.

TECHNICALLY PASSES *BUT NOT REALLY* | From PID control loops to filters loading, mechanical systems are dynamic. If a protective environment (PE) room is designed at precisely the minimum 12 ACH required

and is balanced to exactly the minimum +0.01 In. w.g. required differential pressure; then the space is sure to fail as soon as the keys are turned over to the owner. Buffers need to be both designed and field tuned for system longevity.

WE'RE OUT OF TIME! | A great QA/QC program begins with a realistic project schedule. Developing a schedule that accounts for the time needed to perform testing, identify issues, and address problems is imperative. Furthermore, allocating time to achieve QC measures to ensure testing is successful is equally critical.

A great QA/QC program begins with a realistic project schedule.

Since this paper is about real-world challenges, let's be real – there is never enough time.

Innovative solutions must be implemented to meet the demands of fast pace projects. As aforementioned numerous times, pressure relationships are always unpredictable and time-consuming to correct, especially when the root of the issue is architectural, not mechanical.

Many solutions can be implemented to enhance quality while staying on schedule. One innovative solution we offer is pressure testing the room's envelope while still in the rough-in phase. Using a blower door and building envelope testing methodology, the room's airtightness can be assessed for leaks.

While still feasible both from a time and financial standpoint, identifying and correcting deficiencies early is invaluable for the finished product's quality. Not to mention, no one likes to tear down a finished hard ceiling to access and repair air leaks.

WORST-CASE SCENARIOS | As the testing agency, it is vital to identify the worst-case scenarios and how the rooms and adjacent spaces will be used after occupancy. Seasonal changes will affect pressures, air exchange rates, temperatures, and relative humidity levels, all of which have required design parameters for compliance. During testing, various scenarios should be simulated to identify potential problems before they become actual problems. Do the reheat and cooling coils have adequate capacity? Does the humidifier work? How do economizer, minimum airflow, and maximum airflow affect pressurization?

Seasonal testing is necessary too. While you can simulate many conditions, some issues cannot be identified without the appropriate outdoor ambient conditions. One specific illustration of these issues would be when tuning PID control loops. Additionally, performing traditional seasonal testing at the peak of summer and winter may not be adequate. Unforeseen issues can also arise during heating/cooling transitional periods in the fall and spring seasons, especially relative humidity control.

ATTENTION TO DETAIL (OR THE LACK THEREOF) | At some point or another, everyone has made a mistake. The same is true with ASHRAE 170 compliance testing. We have reviewed hospital spaces that have "passed," but are not compliant in reality. The key to reducing human error is to establish a systematic procedure to alleviate the likelihood of mistakes. This begins with developing a standardized plan and test forms to ensure the accuracy of each test. Often, healthcare systems have multiple testing agencies to test their hospitals for compliance, all of whom have a different methodology, test forms, and procedures. In this case, there is value in standardization at the healthcare system level.

CONCLUSION

From hospital accreditation to infection control, ASHRAE 170 compliance is vital to healthcare systems and the patients they serve. Compliance presents many challenges during the design, construction, and life cycle of the systems. Whether adjusting contract documents, implementing innovative solutions to improve QA/QC efforts, or improving testing procedures – identifying common issues, and implementing strategic mitigation measures is the key to success. While challenging, if it were easy, everyone would be in the market.

Dr. Dale E. Turner put it best when he said, "Some of the best lessons we ever learn are learned from past mistakes. The error of the past is the wisdom and success of the future." Keep track of the issues encountered during testing. Host lessons learned collaborative meetings with team members and clients. Challenges exist to be overcome.

WAR STORIES

This war story goes back to a local college where we were wrapping up a Commissioning job for a customer. We were reviewing the project we had just completed while eating lunch when they mentioned that they were experiencing a problem with a new facility that was less than a year old. The customer had hired another contractor other than Nashville Machine Company to do this installation. The customer had stated that several parties such as the Mechanical Contractor, Engineering Group, Controls Group, and TAB Contractor had reviewed this issue and they had no success in getting this resolved. I would tell the customer that when we finished lunch, we would go to the facility and see what we would observe. The installation was the typical college campus set up with the main plant or Powerhouse being Primary/Secondary and the individual Buildings would have a Two-way Chilled water valve that modulated to maintain a supply water temperature to facility with a dedicated pump or pumps that serves the facility on a VFD with a DP sensor that was 2/3rds the way out the loop and a bypass loop with a check-valve for building recirculation. (See drawing detail below)

The complaints or issue was that the VFD pumps were going to 60 hertz at times with loop DP sensor not being satisfied. What made this situation unusual was the problem would occur intermittently. The controls group had been running trends on multiple points trying to determine what was causing the system to do the things it was doing. Anyway, we decided to make a site visit that day to review. Not sure what we would find, my objective at this point was to review the installation where we could work up a quote to price doing a Commissioning of the Chilled Water hydronic

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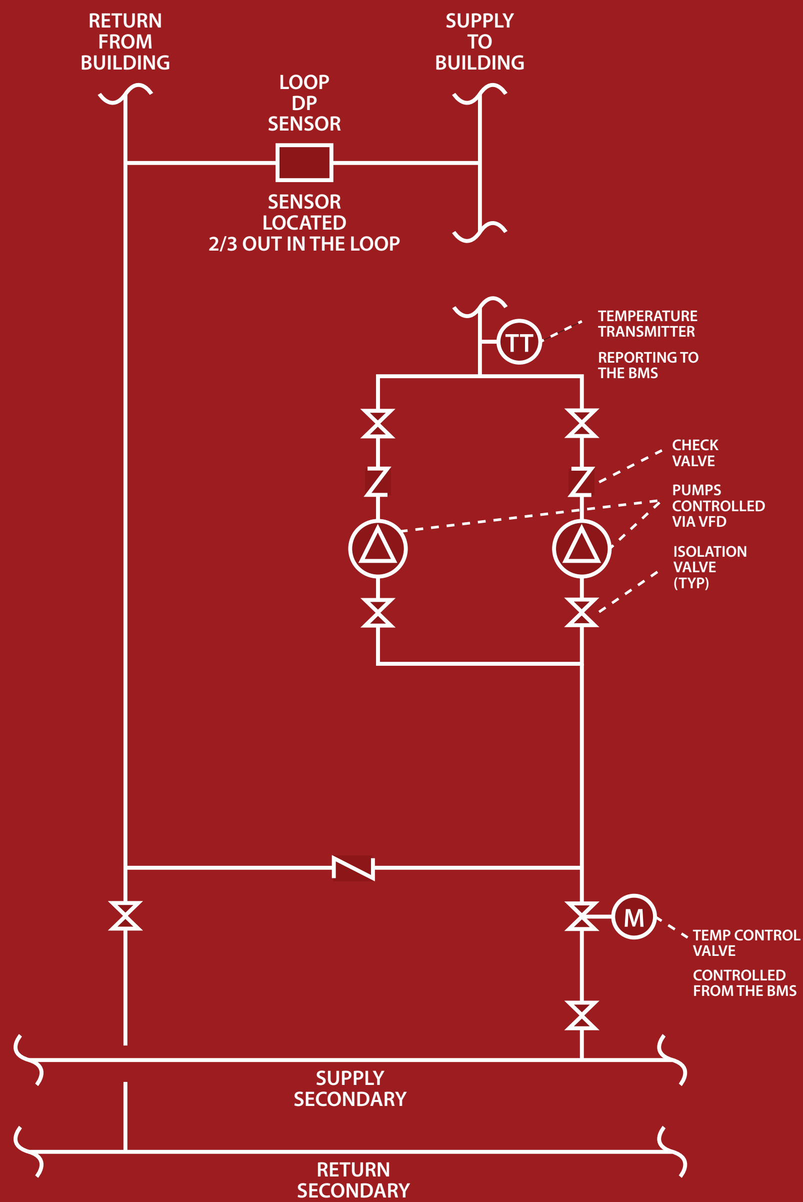
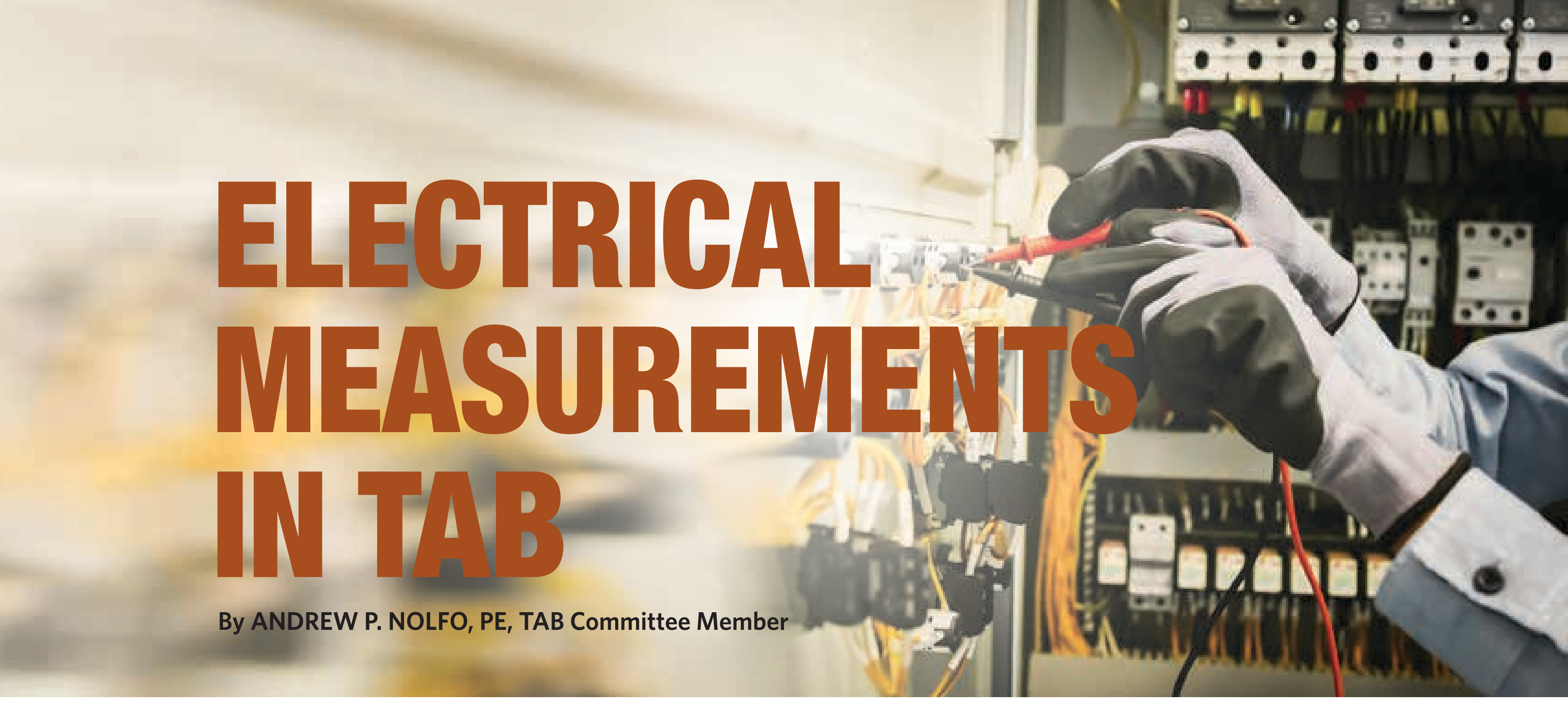
Nashville Machine Company Construction

TEBB Chapter Coordinator and Technical Committee Chair for the Chapter

system for the individual building. Once on site, I started to review the piping installation and traced out how this system was oriented with how the system is typically installed. All looked to be in the correct orientation from what was observed. In listening to what was stated, I asked the Controls technician to reach out to the main BAS Central control and do a couple of things while I watched to see how Building VFD pumps responded. I would first ask them to force the incoming chilled water valve to 100% open. With the valve forced open, we observed the pumps decrease in VFD speed, as to be expected with two-way chilled valves on AHU's, to satisfy and throttle down with Discharge Air temperatures being satisfied. I would then ask for the Central controls to close the main chilled valve for the facility. At this point I observed the VFD speed increase with the single pump and the lag pump stage-up as well until we saw both pumps go to 100% speed or 60 hertz. At this point, I asked what the loop Differential Pressure set point was in relations to actual readings. The loop DP was 0 PSI with two pumps at 60 hertz in parallel. Once this was observed, I then told the Controls technician I knew what the issue was with the overall operation. The Controls technician would look at me confused and puzzled. I told him that the check-valve was in backwards with the cross-over or bypass. I explained to him with the incoming Chilled Water Valve closed the pump was starved of water so the Differential Pressure set point could not be obtained causing the pumps to increase speed. I told him this was not a typical installation to have a check valve installed. This places pumps in series with Secondary Pumps from the Powerhouse. The controls technician would question my observation. So, I asked him to remove the insulation from the check valve to see the directional arrow that is in the casting of the valve. Once he removed the insulation, we saw the check valve was indeed installed backwards. The customer was pleased that we found the issue that had been a problem for over a year in less than 30 minutes. The customer would hire our company to change the orientation of the valve and the facility would function fine afterwards.



The moral of this story is, sometimes the simplest things from an installation standpoint, can have a major impact on how a hydronic system can function or operate.



ELECTRICAL MEASUREMENTS IN TAB

By ANDREW P. NOLFO, PE, TAB Committee Member

I attended the NEBB Annual Meeting in Maui last month and it was a great way to celebrate our NEBB 50th Anniversary. A little windy but a great location, great hotel and excellent technical programs.

One of the technical programs on Friday was presented by the TAB Committee and the presentation highlighted the "new" 9th Edition of the TAB Procedural Standards. I say "new", but it really isn't. It was approved by the NEBB Board of Directors in July of 2019. This program would have been presented at our 2020 NEBB Annual Conference at the Greenbriar Resort in West Virginia in April of 2020. As you are aware, that meeting and the subsequent re-scheduled meetings in June and November of 2020 didn't happen either.

Anyway, at the technical session, there was a good discussion regarding electrical measurements as required by the new TAB Procedural Standard. The discussion centered around taking incoming electrical measurements versus utilizing the values that may be displayed on the VFD screen. One of my old friends from Spokane, Washington made a comment about electrical measurements back in the day versus current technology. That got me thinking about the topic. Thanks Jerry Ensminger.

"...electrical measurements as required by the new TAB Procedural Standard."

When I became a "Qualified Supervisor" (yes, that's what we were called), taking and reporting electrical measurements was a requirement back then. Some of you may remember 1977 when we were still preparing TAB Reports on cave walls and using slide rules with analog instrumentation. Others may have no understanding of what I'm talking about.

The purpose of the electrical measurements back then was to prove to the design engineer that the applied electrical power to the equipment was the proper voltage and that the current draw did not exceed the rated limits. You know what – that's still the purpose regardless of the current technology. Back then, we took electrical measurements on operating equipment with 480v/3Φ power without even knowing how to spell PPE. We will discuss this point later in this article.

While VFD's were non-existent in 1977, they are almost everywhere today with the cost effectiveness of them. Use of VFD's doesn't impact the reason for the TAB firm to report these field measurements. As I stated before, reported measurements of the incoming power to a motor with or without a VFD, identifies to the design engineer, the building's operating personnel and everyone else, that the motor is safe to run. Reporting the VFD's output readings may be a nice feature, it actually has little or no value. The most important measurement that needs to be reported on the TAB Report is the frequency.

EXAMPLE #1

This brings us to my next point – reporting the "Corrected Full Load Amps" (CFLA). Let's use an example of a motor that does not have a VFD and is specified to be 208v/3Φ. The nameplate data identifies that the voltage is 208/3Φ, the full load amps (FLA) are 10.8 amps, and the service factor (SF) is 1.15. On the day that the TAB Technician took the electrical measurements, they he/she reported the following data:

Voltages:	207v	208v	209v
Current:	10.0 a	11.0 a	12.0 a

Since the average voltage is the same as the design voltage, there is no need to calculate the CFLA. And the motor is operating well below the SF amperage. The TAB report would show the 3 voltages and amperages as stated above and would state that the CFLA is 10.8 amps. Additionally, the voltage imbalance and amperage imbalance are well below the requirement ratings in the NEBB TAB Procedural Standard.

EXAMPLE #2

Example #2: Let's do another example. Same motor as above but with different field measurements as follows:

Voltages:	217v	218v	219v
Current:	11.0 a	12.0 a	13.0 a

Since the actual applied voltage is not the same as the design, we must calculate the CFLA. The formula to calculate the CFLA is given by equation #1 below:

EQ #1 $FLA_{actual} = (FLA_{tag} \times E_{tag}) / E_{actual}$

Where:

FLA_{actual} = Corrected Full Load Amps
FLA_{tag} = Nameplate Full Load Amps
E_{actual} = Actual Field Voltage
E_{tag} = Nameplate Voltage

Now we can calculate the CFLA using equation #1 and our field data.

EQ #1 $FLA_{actual} = (FLA_{tag} \times E_{tag}) / E_{actual}$
$FLA_{actual} = (10.8\text{ a} \times 208\text{v}) / 218\text{v} = 10.3\text{ amps}$

For Example #2, the average current is 12.0 amps. Since the CFLA is 10.3 amps and the SF is 1.15, the maximum safe operating current is: 10.3 x 1.15 = 11.8 amps. We are slightly exceeding the safe limits for this motor. This should be reported as a deficiency on the TAB Report if the condition could not be corrected in the field. So, the TAB Report should identify the 3 voltages and amperages as shown above the CFLA for this example would be reported as 10.3 amps.

EXAMPLE #3

Now, let's make it a little more complex. We now have a VFD installed for this motor. All operating characteristics remain the same as the previous examples. The system has been balanced to within NEBB requirements and the final incoming electrical data is as shown below:

Voltages:	207v	208v	209v
Current:	6.5 a	7.0 a	7.5 a
Frequency:	42 Hz		

The display on the VFD will **NOT** be the same as the incoming power, either voltage or current. They will be whatever the VFD electronics calculate is needed to drive the motor at 42 Hz. The electrical measurement for this TAB Report should indicate the voltages, currents, frequency shown above and the CFLA would be reported as 10.8 amperes. The voltages and amperages on the load side of the VFD have no significance in determining if the motor is safe to operate. I think it's an excellent practice to report these values, but they are meaningless when you understand the exact purpose of taking electrical measurements for TAB work. You must understand that the VFD will provide the power (both voltage and current) that is needed at the operating frequency. Even if the operating frequency is 60 Hz, the load side of the VFD may not replicate the exact same values as the incoming power characteristics. The incoming power is what needs to be reported in the TAB Report.

"…the most important investment is the education and safety of the firm's personnel."

Another feature that is often overlooked are voltage imbalance and amperage imbalance. The NEBB TAB Procedural Standard going back to the 3rd Edition in 2005 has stated that a voltage imbalance exceeding 2% of the average voltage and or an amperage imbalance exceeding 10% of the average amperage is considered a deficiency and must be reported in the TAB Report. Additionally, voltage imbalance issues may be an indication of power issues within the facility and should be reported to the proper personnel. An amperage imbalance may be indicative of an internal fault within the motor.

Let's close with a short discussion about taking TAB electrical measurements in the field today. While a firm's instruments, vehicles, etc. may be their largest capital investment, the most important investment is the education and safety of the firm's personnel. If your firm employs properly trained personal who use the correct protective gear, then I have no issue with your firm taking the required TAB electrical measurements. If your firm does NOT employ such a person, I would recommend that all TAB Electrical measurements be taken by properly trained persons with the proper protective gear using your firm's calibrated electrical instrumentation.

Conclusion: Electrical measurements for TAB work should always be the values of the incoming power source to the installation. This is true regardless of whether there is a VFD serving a motor or not. A recommendation would be that the next edition of the TAB Procedural Standards provides a better-defined position on electrical measurements that would include the electrical measurements of the incoming power characteristics. Additionally, if the equipment is provided with a VFD, then the frequency and electrical characteristics of the load side the VFD would be required and must be reported in the TAB Report. Corrected Full Load Amps are required by NEBB and must be included in the TAB Report. Our NEBB Certified TAB Firms need to pay attention to voltage imbalance and amperage imbalance. Finally, we need to protect our employees by ensuring that all electrical measurements are taken by properly trained personnel with the correct protective gear. ●

NEBB Seminars: Focusing on Safety

By Kerri Souilliard and Christina Spence

When the pandemic took hold of the world last year, NEBB leadership faced many important decisions regarding scheduled activities, including seminars for NEBB's various disciplines. Ultimately, to err on the side of caution, all 2020 NEBB seminars were canceled.

"After a year of craving in-person instruction, NEBB is proud to say seminars are back," stated NEBB Executive Assistant Christina Spence. "In order to bring back NEBB seminars in April this year, several changes regarding the safety of attendees and instructors were in order."

With a focus on new protocols to prevent the spread of Covid-19, NEBB has worked hard to be able to offer training seminars that continue the quality instruction in NEBB disciplines that NEBB is known for.

How NEBB is Ensuring Safety

Following state and local laws, NEBB has implemented changes focused on the safety of all involved. One major change is the maximum number of participants accepted for a training seminar. While the number of participants easily totaled 30 registrants or more in the past, the number of participants per seminar is now capped at 12 total. The reason for this change is to allow for proper social distancing of 6 feet between each person within the seminar room. For this reason alone, many seminars have had a wait list this year. When possible, participants are encouraged to register early!

NEBB is also focusing on increased protection of high touch surfaces within the seminar setting. Part of NEBB's Covid-19 Response Plan which can be found in each seminar brochure reads, "Precautions such as constant sanitization of the seminar area, increased attention to high-touch areas in the rooms, limits on the number of attendees during the seminar, and protective gear for our instructors are in place."

Assuring minimal contact between participants, boxed lunches have become the standard for the luncheon provided at seminars.

Participants' Responsibilities for Staying Safe

Just as NEBB is doing its part to ensure the safety of seminar attendees and instructors, NEBB seminar participants are required to comply with specific requirements in order to attend a seminar. To ensure these responsibilities are understood, participants must submit a Covid-19 Waiver prior to their seminar of choice.

If you are experiencing any symptoms of COVID-19 like running a fever, coughing or shortness of breath, NEBB asks that you do not attend the seminar at all. You may call or email the NEBB Headquarters to easily reschedule for a new date.

Once participants arrive, masks are required for the duration of the seminar. Gloves can be worn if desired but are not mandatory.

Additionally, participants are also asked to sanitize their hands prior to entering the area of seminar instruction, as well as to avoid shaking hands or engaging in any unnecessary physical contact with others at the seminar.

If we all do our part to ensure a safe atmosphere for NEBB seminars, together we can continue to enjoy the unique learning environment that NEBB professionals and technicians have always used to master NEBB disciplines.

The NEBB Seminar schedule for 2022 is now available. Be sure to take a look and sign up early for any seminars you wish to attend! ●

NEBB 2022 TECHNICAL SEMINAR SCHEDULE

Interested in attending a seminar?

Follow these simple steps:

1. Go to www.nebb.org click on events and select your seminar.

2. Download the brochure, complete the registration form and send with payment to training@nebb.org or register online using the Certelligence Portal.

NEBB
8575 Grovemont Circle
Gaithersburg, MD 20877
301.977.3698

March

Testing, Adjusting, and Balancing (TAB)
March 24 – 27
IMI TA Balancing, Roswell, GA
Registration Deadline:
February 24, 2022
Optional Exam Days:
March 28, 2022

April

Cleanroom Performance Testing (CPT)
April 4 – 6, 2022
NEBB Tec, Gaithersburg, MD
Registration Deadline:
March 04, 2022
Optional Exam Days:
April 7, 2022

Sound & Vibration Measurement (S&V)
April 4 – 8, 2022
Total Dynamic, Deerfield Beach, FL
Registration Deadline:
March 04, 2022
Optional Exam Days:
April 6 & 8, 2022

June

Testing, Adjusting, and Balancing (TAB)
June 9 – 12, 2022
NEBB TEC, Gaithersburg, MD
Registration Deadline:
May 09, 2022
Optional Exam Days:
June 13, 2022

Fume Hood Performance Testing (FHT)
June 6 – 7, 2022
Labconco, Kansas City, MO
Registration Deadline:
May 06, 2022
Optional Exam Days:
June 8 – 9, 2022

September

Cleanroom Performance Testing (CPT)
September 12 –14, 2022
NEBB Tec, Gaithersburg, MD
Registration Deadline:
August 12, 2022
Optional Exam Days:
September 15, 2022

Testing, Adjusting, and Balancing (TAB)
September 15 – 18 2022
IMI Training Center, Dallas, TX
Registration Deadline:
August 15, 2022
Optional Exam Days:
September 19, 2022

October

Building Enclosure Testing (BET)
October 31 – November 1, 2022
Belmond Charleston Place, Charleston, SC
Registration Deadline:
September 30, 2022
Optional Exam Days:
November 2, 2022

NEBB 50th Annive

2021 NEBB Annual Conference
Honoring Our Legacy • 1971–2021

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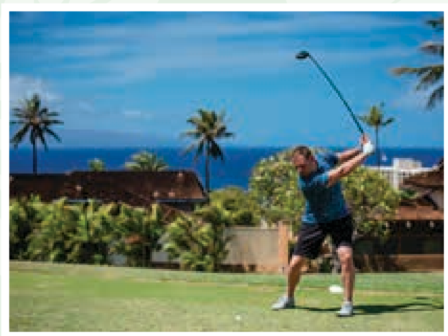

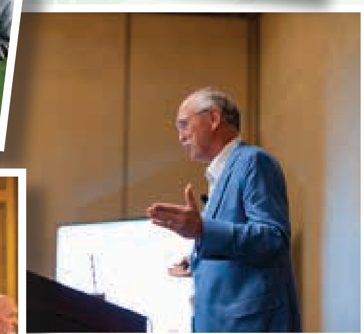

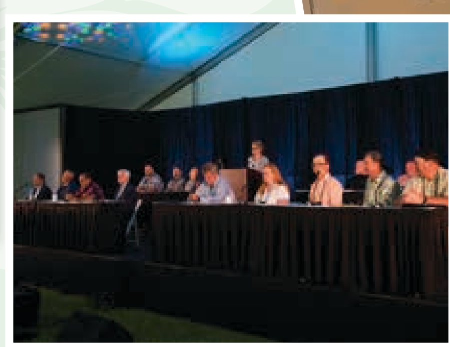

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Chapter News

MAEBA

Trish Casey, Chapter Coordinator

After having to skip last year's seminar due to COVID-19, MAEBA has scheduled their Semi-Annual Meeting on April 22, 2022, at the Radisson Hotel in Trevose, Pennsylvania. This is a three-hour educational session geared toward the Certified Technicians, but all are welcome. The seminar begins with lunch with the Vendors, followed by the seminar.

MAEBA will also be holding their Annual Recertification Seminar next September 2022 (date to be announced). The Recertification Seminar will be extra special next year since MAEBA will be celebrating their 50th Anniversary!

Lastly, MAEBA would like to congratulate our own, Jeffrey Schools for being hired as the NEBB National Technical Director. Jeff has been a long time MAEBA Board of Director, Technical Committee Member and Exam Proctor. We are excited to share Jeff's expertise with the entire NEBB organization.

Mid-South EBB Chapter (MEBB)

Ginger Slaick, Chapter Coordinator

Mid-South EBB held its Recertification Seminar and Vendor Expo September 18th – 19th at the Battle House Renaissance Hotel & Spa in Mobile, AL. It was a successful in-person seminar that provided relevant continuing education for CPs and CTs. Mid-South EBB also offered a live-stream option allowing those with special circumstances the opportunity to still participate.

The seminar attendees took a field trip to Gulf Quest National Maritime Museum to learn about the museum's mechanical system including Cascading Boiler Fundamentals – operations and controls; Hydronic Technologies, HVAC Design Intent, Controls (Wireless), Large AHU (Installation, Controls, Strategies), VFD, and Ductwork Installation from the professionals involved in the design and install of the project. The rest of the seminar was filled with technical sessions on Siemens ABT Software, Chilled Plant Optimization, Stack Effect-Building Pressure Control, and Cyber Crime and Security – Part II.

Vendors and door prize winners.

The Vendor Expo was also a success. Throughout the day, attendees had the opportunity to visit vendor booths and learn about the latest instruments, software, and products offered. To conclude the event, the vendors drew names and handed out door prizes. Special thanks to Evergreen Telemetry, Instruments Direct, Retrotec, Testo, TAB Opts (Ameritech Data Solutions), TSI, Dwyer, Building Start, and Performance Instruments for their continued support of the Mid-South EBB chapter.

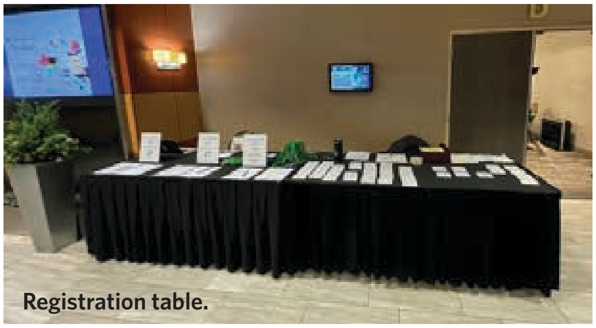
North Central NEBB

Ashley Lang, Chapter Coordinator

North Central NEBB held their Recertification Seminar on Thursday, October 14th at the Doubletree in Roseville, MN. We had 64 registered attendees, down from previous years, but still a good turnout.

We had 6 vendors (Ameritech Data Solutions, Building Start, Dwyer Instruments, Evergreen Telemetry, TMS Johnson and TSI) and 6 speakers – Jeffrey Schools, Dan Chudecke (Mulcahy), Derek Hedrick (Ameritech Data Solutions), Jay Denny (U OF M), John Rutledge (Corval Group) and Nathan Vaughn (Price Industries).

Overall, the seminar was a success and we are looking forward to next year!


Registration table.


Seminar attendees.

Southern California EBB (NEBB) Awards The Bill Blackstone Lifetime Achievement Award

NEBB
SOUTHERN CALIFORNIA CHAPTER

On August 27, 2021, the Southern California EBB Chapter presented Bill Blackstone an award for outstanding achievement in our industry.

Bill worked in the architecture field after college. In 1968, he went back to college and worked for Cal-Air in the Estimating department. After 3.5 years he moved to United Air Conditioning as a sales person, working for commission only. This was when Bill knew that he had a future in the business.

Unfortunately, United suffered some profit losses and his monies were held up forcing him to move on. He got a call from Cal-Air offering him a position. For the next 18 years, Bill would work his way up to becoming President.

This took a toll on his health forcing him to retire early. After recovering from a by-pass surgery, he joined SMACNA Los Angeles as the Technical Consultant. He was also given the Southen California EBB Chapter to lead, which he did for 25 years.

He marketed our group with SMACNA at no cost to our chapter working with the State Architect office to get NEBB in Spec's, as you see it on almost every set of Drawings.

Bill is also an author with high praise due to his works on fly fishing. He is the 16th recepient of the prestigious Buz Buszek Memorial Fly Tying Award.

This award may never be given to another person due to Bill setting such high standards. We, the members of Southern California EBB, can only say **THANK YOU** for all you have done in Life and the Industry you Love.

NEBB
8575 Grovemont Circle
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USA

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