FUME HOODS AND LABORATORY AIR FLOW SYSTEMS: LESSONS, FEATURE, AND IMPROVEMENTS, FROM THE "OLD SAINTS" OF THE ATOMIC ENERGY ERA THROUGH TODAY

by

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ABSTRACT

Laboratory Air Flow Controls Systems (LAFCS) development efforts began in earnest in the 1940s. A wartime nation in an intensive effort to develop an atomic bomb focused the attention of some of our best scientific and engineering professionals to enhance safety laboratory safety. The industry learned a great deal during the "AEC era" about fume hoods, laboratory and hood containment and what worked and did not work and why. Many of the major problems identified during this era have been ignored and have continued to plague performance during the brief resurgent era of the mid-1970s and resurfaced again in the resurgent era starting in the late 1980s. While energy and operational cost avoidance savings has been touted as the justifying factor in these resurgent eras, better containment in fume hoods and work spaces was the justifying factors with the "Old Saints" in the AEC era.

Most often laboratory work spaces involve use of flammable or explosive, carcinogenic or suspected carcinogenic, pathogenic, corrosive or otherwise hazardous chemicals or agents. In all cases, however, the major concern driving development of LAFCS, should be proper and reliability control and resulting containment function. But what is it?

This presentation will trace the LAFCS efforts starting with the "Old Saints" and trace the concepts developed, tested and in some cases abandoned with LAFCS hardware. Concept defects and risk factors will be identified, and in some cases illustrated with news clips as LAFCS have now finally begun to reach useful and cost justified maturity.

PURPOSE

The purpose of this presentation is to identify and define the aspects of laboratory air flow systems performance that engineering can impact and to review lessons we should have learned from past efforts concerning features, functions and benefits that should be incorporated in present laboratory efforts. The major engineering concern, certainly the one that proper engineering can impact, is associated with the laboratory air flow system delivery and containment achieved. This paper reviews constraints along with engineered measures that can be employed to avoid or reduce exposure to known chemical or biological laboratory safety related problems which have a negative impact on: the lives of individuals working in the laboratory, public health, safety, and welfare of individuals working in the laboratories or in support of activities in the laboratory, including a reduction in property or economic considerations arising from accidents or other problems in laboratories.

We all realize that as long as people are involved, laboratories will never be 100% safe. For example, there are no engineering solutions that can protect a laboratory user from self-folly such as conducting experiments on a bench that should be conducted within a fume hood. However, with advancing and improving technology, significant engineered system improvements have been made which can be incorporated into existing and new laboratories to significantly minimize risk, while at the same time, significantly enhancing performance and reducing operating cost. Further, we can use engineering solutions to maximize containment control regardless of the material used within a fume hood. On this basis we seek, through engineered solutions, a reduction in risk to laboratory users associated with fires, acute or chronic carcinogenic, radioactive, or biological materials exposures; and costs associated with damages including repairs and clean-up costs.

LABORATORIES AND USER RISK

Laboratories are dangerous places. A search for headlines which have appeared in newspapers over recent years concerning laboratory users and related health and safety concerns has identified the following.

> Fire related problems, including risk of explosion and burn damages to facilities and users.
>
> Carcinogenic, radioactive, or biological material exposure related problems, especially those that are chronic in nature and start with initial exposure sometimes as far as twenty years in advance to detection of a problem.

LABORATORY AIRFLOW SYSTEM GOALS

The primary goal of any laboratory air flow and ventilation system is to create a safe working environment subject to "fail safe" considerations in all possible scenarios. Energy savings therefore, must be a secondary goal. To accomplish this primary goal, certain conditions must be met in laboratories such as:

> First, maximum containment of materials in the fume hood under all operating conditions.
>
> Second, maximum containment of materials in the room that houses the fume hood under all operating conditions.
>
> Finally, if possible, provide comfort conditions for users working in the rooms that house the hoods.

HISTORICAL BACKGROUND

Concerns about proper laboratory air flow and ventilation systems, including fume hood performance, and the significant advances made concerning user safety, traces back to work done in the early 1940s in Atomic Energy Commission (AEC) laboratories. Concerns and findings were investigated extensively during the late 1940s, with corrections made immediately when recognized. Findings generated during this time were most often classified and only declassified in the late 1940s and early 1950s, after World War II ended. The tremendous effort and historical data associated with the Atomic Energy Commission (AEC) effort at that time repeatedly indicated that the primary issues of concern that should be addressed in laboratory air flow system design are simple and are as follows.

> Maintain fume hood face velocity constant at all openings regardless of static or dynamic hood sash position or airflow control system response dynamics. Always keep the hood sash at its minimum opening. Select hoods on the basis of their aerodynamic characteristics, including airfoils, shingling type baffles, curved sidewalls sections, full slot pickup across the back baffles, etc. Design the laboratory air supply systems so the supply flow does not cause disruptive drafts in the work space.

These concerns are of equal importance and apply to all laboratories regardless of the goal sought: *enhanced containment for safety or energy savings*, especially items A and B. In the 1940s we had a wartime effort directed at rapidly solving a problem. We created the A-bomb so we could save lives rather than incur the high cost to invade Japan. We focused some of the best minds on defining laboratory problems, especially air flow and containment problems, and worked feverishly to accomplish this goal. Most often this was done without concern for cost. We lost lives during the wartime AEC effort because of ignorance on the part of the users and laboratory designers, among other reasons. When we discovered a problem, however, we most often took corrective action to solve it. And if a mistake had been made, we admitted them, corrected them and went on. Further, the time constraints associated with the goal of the creation of an A-bomb and the Cold War of the 1950s would not allow the luxury of finger pointing, ego and turf protection, and low bid folly.

After World War II, as the atomic era hay day began to wane, we transitioned into the chemical era where the exposures were not perceived to be as dangerous as they were in the atomic era. Further, profits became more important than completion of a bomb. Products were therefore cheapened, *especially* fume hoods, by making them simpler to manufacturer rather than making them contain better. Our desire to build things cheap also became evident with other items where performance gave way to cost of manufacturing. Price and simplicity drove low bid awards and we began to sacrifice performance for price. Also during this time, the "old saints", those individuals who spent so much time trying, failing, and learning, began to leave their professions and retire. The emphasis was not present in the industry to sustain the applications research and development efforts that had been associated with solving laboratory air flow and containment problems. Moreover, acute problems of the atomic era gave way to the chronic problems of the chemical era. Finally while some of the application information was put to paper, a great deal of this knowledge was lost simply because application research funding was reduced and there were no young professionals entering this work area to pass the information down to. Subject to these factors, perhaps it would be wise if we were to re-examine what has already been learned by the Old Saints and ignored and forgotten by new generation professionals.

MAINTAIN FUME HOOD FACE VELOCITY CONSTANT AT ALL OPENINGS REGARDLESS OF STATIC OR DYNAMIC OF HOOD SASH POSITION OR AIRFLOW CONTROL SYSTEM RESPONSE DYNAMICS

The first reference to this concern found was John Weber, Jr.'s disclosure United States Atomic Energy Commission paper, AECD-2380, *A Mechanism for Automatic and Manual Control of the Air Velocity at the Window Opening of Fume Hoods.* This paper is attached and we will discuss it at length. Note that while he was concerned with constant face velocity into the hood, the systems were draw through only; non-air conditioned and thus no room supply except for a louver in the door. Note also that he was concerned because of "...controlled velocity action through the face opening of the hood without causing turbulence or other air action sufficient to cause eddy currents, back drafts, etc..."

This concern was also identified and addressed in the *Proceeding Laboratory Design for Handling Radioactive Material*, National Research Council, BRAB conference report no 3, November 27, 1951, pages 26 and 47, among other places. Indeed, page 27 identifies the type of hood arrangements and face velocity limitations associated with each type of arrangement. Page 26 identifies experience-gained factors concerning desirable face velocity. Notice that in past published literature, no group endorsed a particular face velocity value, always leaving this to the "professional judgement" of those concerned with the safety of each situation.

Homer B. Clay's article, *Controlling Fume Hood Exhaust in Atomic Energy Laboratories*, published in HPAC July, 1950, pages 77-83 discusses the first "through-the-wall" hot-wire "..face velocity.." control that was mounted in the hood side wall. It was a Honeywell device. Significantly he also provided engineering reasons for having fume hood face velocities something on the order of 100 feet per minute. He also identified the basis problem associated with the low order differential pressure (i.e., 0.000624" WC) needed to produce 100 fpm velocity, either through a hood sash opening or room door.

ALWAYS KEEP THE HOOD SASH AT ITS MINIMUM OPENING

What this concern amounts to is (1) closing the hood when someone is not in front of it and (2) keeping the sash at a minimum opening, typically no higher than 18" for a vertical rising sash hood, when someone is working in front of the hood. Minimum opening affords much better containment with smaller openings and protection of one's upper body via the special tempered safety glass barrier, should a fire or an explosion occur. While not always expressly stated in this fashion, Weber (1946) implies "keep the hood closed". The Nation Research Council Proceeding (1951) reflects "keep the hood at minimum sash position"; Homer B. Clay's article, *Controlling Fume Hood Exhaust in Atomic Energy Laboratories*, published in HPAC July, 1950, pages 77-83 indicates the reasons for keeping the sash at its minimum open position. H. W. Alyea's *REDUCING AIR EXHAUST OF LABORATORY FUME HOODS*, published in HPAC February, 1951, page 80, explicitly states "Since the hood doors are kept closed as much as possible for reasons of safety..." as the explanation for this.

SELECT HOODS ON THE BASIS OF THEIR AERODYNAMIC CHARACTERISTICS INCLUDING AIRFOILS, SHINGLING TYPE BAFFLES, CURVED ENTRANCE SIDEWALL SECTIONS, FULL SLOT PICKUP ACROSS THE BACK BAFFLES, ETC.

Fume hoods were initially developed for containment by incorporating geometric designs based on aerodynamic airfoil. Styles and shapes of fume hood openings and baffling arrangement, especially the sidewall foils, have changed over the years to (a) reduce manufacturer's cost, (b) accommodate some special need or (c) enhance aesthetics. Unfortunately, in this regard, we have had a tendency to "throw the baby out of the bath water" to get the baby clean which we all know really does not work. Consider the sketches provided from presentations made by John Clark, now long retired from Oak Ridge National Laboratory who was active when much of the 1950 to 1970 era work was being developed. Note next drawings associated with a fume hood that was developed in response to improvements suggested for hood design test extracted from Cynthia Vickery's master thesis, *An Evaluation of a Prototype Laboratory Fume Hood for Use in a Variable Air Volume, Constant Face Velocity System*, Texas A&M University, Industrial Hygiene, December, 1992.

Note that use of outside air make up hoods is as being undesirable was initially stated as undesirable in *Proceeding Laboratory Design for Handling Radioactive Material*, National Research Council, BRAB conference report no 3, November 27, 1951, pages 26.

DESIGN THE LABORATORY AIR SUPPLY SYSTEMS PROPERLY SO THE SUPPLY FLOW DOES NOT CAUSE DISRUPTIVE DRAFTS IN THE WORK SPACE

Best containment in a fume hood result from the fume hood being allowed to "draw" air into it through the open sash (as opposed to any supply system "blowing" interference) and result with supply air flow control dynamics associated with offset air flow tracking where with supply side control response is slaved to hood and room air exhaust flow control. This finding was implied by Weber as early as 1946. *Proceeding Laboratory Design for Handling Radioactive Material*, National Research Council, discusses this consideration at length in 1951 and do other long dated publications.

We progressed along in the 1970s with the energy crisis and in the mid-1980s saw oil prices go up and out of site. Big at that time was still good, both in terms of number and size of "toys," and in number of employees. We built some very big labs in the late 1970s and early 1980s, including the Amoco Naperville Facility, the Exxon Clinton Facility, and the Arco Plano Texas project. Alas, toward the 1980s we began to lay people off and it became a curse to be over 50 and employed by a major oil or chemical company. The "bottom line" and Return on Investment were the only things that counted, and another "layer" of time proven, experienced laboratory engineers left the industrial ranks and, greater health problems began to worsen for the remaining workers. Young and inexperienced became the vogue and major companies realized that while the young would make costly mistakes, the companies would save offsetting costs because the average age of the technical staff, which had been greatly thinned, had been greatly reduced along with benefit cost. Moreover, many of those laboratory works with earlier contacted chronic problems that were beginning to surface had began to retired and without diagnosis of problems or causation.

SO WHAT CAN YOU DO ABOUT IT?

In an excellent paper published in the February, 1998 American Industrial Hygiene Association Journal, entitled Reducing Employee Exposure Potential Using the *ASHRAE/ANSI 110 Method of Testing Performance of Laboratory Fume Hoods as a Diagnostic Tool*, Karen Maupins and Dale T. Hitchings recommended that traditional face velocity testing alone be discontinued in favor of the ASHRAE 110 method as a qualitative measure of fume hood performance. They advocate use of the ASHRAE 110 method coupled with the traditional face velocity measurement at periodic intervals to assure continued performance. While all should agree that face velocity alone in not a significant and meaningful indicator of containment assurance in a fume hood, all should also argue that if a laboratory design and its equipment adhere concurrently to the basic principles defined above by the Old Saints, maximum containment performance will always be ensured.

Clearly returning to conformance to the basic concepts identified by the "Old Saints" above, represents a necessary starting point for gaining optimum containment performance with laboratory fume hoods or with laboratory air flow control systems that serve hoods and room environments.

Equally impressive in this paper is the attempt by the authors to put in writing a brief mitigation to correct defects found in an older laboratory complex. Expanding on the scope of this goal, the following if offered.

DESIGNS FOR NEW BUILDING

Designs incorporating the four basic ventilation concepts identified above have consistently proven to have best performance, and significantly have proven to have lowest first mechanical cost and much lower operating cost with consistently demonstrated superior ventilation containment performance. Remembering that laboratory containment safety centers around the installation of a proper and well-maintained ventilation system, we know from work of others in the 1940s and 1950s AEC era that fume hood containment is greatly improved if the face velocity can be maintained constant at all fume hood sash openings. Weber and others proved this with numerous published results, including the need to control fume hood face velocity constant at all sash positions and incorporate into facilities designs means of keeping the hood sash always at minimum position. Obviously the supply-side air cannot interfere with hood capture performance or fume hoods with properly design airfoils and other amenities which go a long way in aiding capture and containment performance, that if once established, has the potential to consistently perform. And contrary to the beliefs of some, constant volume air systems in laboratories cannot guarantee best performance and in most cases do not yield capture/containment results that are best achieved by variable air volume laboratory systems. However, constant volume laboratory air systems do offer better dilution protection for events occurring outside the hoods.

MITIGATION PLANS FOR EXISTING BUILDINGS

The following expands on the Mitigation Plan presented in the Maupins/Hitchings paper and should be of special interest to campus safety professionals. First and foremost, concurrent compliance with the four basic ventilation/containment enhancement constraint concepts identified above represent an initial starting point in any mitigation plan. Additional containment enhancement modifications are as follows:

Fume hood repairs and modifications: Maupins and Hitchings pointed out that containment enhancement in fume hoods could be improved if missing interior panels were replaced. Because there is rarely any maintenance done on fume hoods once installed, except for failure repairs, restoration of proper operation of bearing and pulleys on sash devices, including wheels and slides, can greatly improve proper hood operation. In addition to replacement of interior panels, our firm has also benefited containment performance by converted combination sash type hoods to vertical rising sash type "in place". This has been done by changing the "front end" of hoods and at a cost significantly lower than new hood replacement. We have also replaced liners "in place," and modified the baffles and counter tops of hoods. In addition we have installed "add on" air foil sheet metal shoes around the sash opening of hood with great containment improvement, especially where a hood has square corner posts. These are low cost, yet effective, changes that can be made to almost any fume hood, "in place" that will enhance containment performance.

A sash cap installed atop a hood that eliminates air flow into a hood in the case of conversion of hood operation to constant face velocity, variable exhaust flow can dramatically and favorably influence hood containment performance. Installation of the sash cap seals off the escape path that normally exists between the sash at the top of the hood and slot in the top of the hood, and especially the gap between them. Installation of sash caps on constant volume hoods can also be beneficial, especially when thermally driven buoyant forced are acting in the hood to drive the air upward within the hood; a sash cap can often prevent fugitive emission escape from within the hood into the room when the buoyant driving forces are greater than the velocity forces acting to contain the material in the top of the hood when this air gap is present.

Baffle and hood discharge modification: As Maupins and Hitchings pointed out, baffle replacement or repair can help in ensuring uniformity of capture velocity across the opening of a hood. While adjustment of the baffles in an existing hood can also help, greater hood performance always seems to occur if the baffling in the hood can be converted to the shingled-type arrangement rather than the simple slot arrangement. This is especially true if the single large upper baffle in a hood is used to form a low pressure plenum in the top of the hood above the work space cavity with exhaust connected to a single round duct from atop the hood. If this baffling arrangement can be replaced with a slot-type baffle across the entire top of the hood, especially in combination with the hood being served by a single-type baffling arrangement, hood containment is enhanced.

Sash Position/Volume Optimization: Although Maupins and Hitchings pointed out that some hoods allow excessive vertical operation and suggested installation of sash stops to control normal upward displacement, a better way exist to address the consideration. Their suggestion of re-adjustment of fan speed to establish desired face velocity through the smaller sash opening can prove detrimental in some instances.

A patented hardware system now exist that incorporates a photoeye/presence sensor installed on any vertical rising sash hood that opens the hood sash to one or more user selected heights when the user approaches the hood. The sensor then closes the hood after a brief delay, when the user exits the presence zone, in front of the hood.

When this feature is installed in a hood in conjunction with a constant hood face velocity control system, maximum containment on any vertical rising sash hood, as was first identified by Weber in the 1940s, is achieved. Interlocking of the analog closed loop hood and laboratory air flow system to the automatic sash positioning system can further be used to enhance containment; the controls can be made to automatically but gently shut the hood sash to the best safe operating position when a low flow situation exist.

Best safe operating position is when set-point hood face velocity is achieved by closing the sash when insufficient hood exhaust flow exists for an initially selected hood sash opening. This situation can occur for example when the user selector switch controlling sash position (half height vs. full sash opening) is set at half height position and the user manually opens the sash beyond this position for experiment "set-up" or other reasons. If the hood exhaust flow is satisfactory at half height but insufficient in this instance for proper containment at the three-quarter opening position, the controls will close the sash to a position somewhere between half and three-quarters positions to achieve set point face velocity, nominally 100 fpm in most instances. Another example of this situation is some times encountered when a fan belt may be slipping on a hood exhaust fan causing loss of required flow needed at a particular sash opening to produce the set-point flow.

This simple low cost enhancement is also used to cause the sash to go closed when no hood exhaust flow exists or causes closure of the sash with high flow room and hood purge when one or a combination of high temperature or concentration sensors located in the room or in the hood are automatically activated in an upset condition and manually triggered by a push-button switch best located by a door when a user exists the room in an emergency situation.

Supply Air Upgrade: Maupins and Hitchings correctly pointed out that supply air blowing perpendicular to or normal into the hood opening at velocities exceeding 30% of average face velocity can interfere with the normal "drawing" of air into the hood through the hood face. Air blowing perpendicular to the normal path of air entering a hood through the hood sash is the problem that normally encountered with outside make-up air hoods.

If the terminal velocity of supply air at the hood sash opening is greater than the average velocity of the hood, the supply air stream can eliminate any containment within the hood. This situation occurs when a supply diffuser is located to close to the hood or where the supply air is not induced into the hood by the action of pulling or suction action of air into the hood caused by the hood exhaust system.

Weber recognized that air flow pattern cause by the flow of make up air into a hood could cause significant problems when he sought control of "...velocity action through the face opening of the hood without causing turbulence or other air action sufficient to cause eddy currents, back drafts, etc...". The systems then in use had no forced supply, however.

While forced supply air induced problems can be corrected in some instances by removal of or relocation of an offending supply air diffuser, the type of supply air flow control system, i.e., flow tracking or room to hall pressurization, can each also cause "...turbulence or other..." air flow problems in a hood face. Tests have consistently shown however that room and especially hood containment performance is best achieved with a supply vs. exhaust flow tracking concept based system rather than by a differential pressurization concept based system. This is explained by the fact that all differential pressure type control systems allow a sudden high volume inrush disruptive "burst" of air that disrupts air flow patterns when the room to hall differential pressure control system is upset. This problem is more pronounced the closer a hood is located to an influencing door or room supply diffuser. And, while some "air bursting" occurs with a flow tracking system, the differential pressure levels caused by control system response that produce disruptive air burst and resulting turbulence in a room or hood is less sever with a tracking control concept than with a differential pressurization concept.

Supply Air Balance: Maupins and Hitchings correctly pointed out that supply vs. exhaust flow balance in laboratory air flow systems must be maintained to ensure a slight negative differential pressure and resulting infiltration in a laboratory from adjacent corridors or rooms occurs. This is a safety/containment requirement that is addressed in NFPA 45. However, in addition to the problems of where and how introduction of air into an room occurs and how it impacts air flow and best flow patterns into the hood through the hood sash opening, the problem of insufficient make up air needed for proper hood exhaust must also be addressed.

The insufficient room supply air make up problem is more prevalent in older laboratories than newer laboratories, especially where additional hoods and exhaust devices have been added without increasing capacity of the supply system. Air flow in rooms and hoods associated with these system always exhibit containment, turbulent, "air bursting" and other disruptive problems. Fortunately, in laboratory where this has occurred, a control based solution exist that can allow for supply system "catch up" to exhaust system demands. By going to constant face velocity, variable hood exhaust flow control with application to a room supply air flow tracking concept, exhaust demand is reduced when hood sashes are closed. Because hood users do not work in front of hood at all times, if hoods are equipped with automatic sash positioning systems (ASPS), diversity of hood use can be used to reduce net hood exhaust and allow cost savings "supply flow system catch-up". Fortunately changes to existing system needed to allow installation of hardware needed to accomplish this goal are not significant and the changes, being control changes can generally be done without disruptive air handler, supply or exhaust systems, associated duct changes, or long term system operations.

Installation of Specific Exhaust: Maupins and Hitchings correctly pointed out that often equipment is placed in a fume hood that blocks air flow and impairs hood performance. These devices can often be removed, placed on benches and vented with special exhaust, thus satisfying their special exhaust requirements. If it is necessary to install such devices in fume hoods, installation should require specialty hood and benches that allow extended depth within the hood. Venting an acid storage cabinet or flammable storage cabinet through the back work space of a hood work surface for example should not be done and all NFPA 30 fire cabinets for flammable material storage should be ventilated through that laboratory exhaust system.

Rearrangement of Associated Equipment: Maupins and Hitchings correctly pointed out that the rearrangement of equipment, both within and outside a hood, can often favorably impact hood performance. This may mean installation of custom built racks, stands or similar devices to allow installation, separation, or elevation of elements in a hood thereby allowing surrounding air flow. Ideally nothing should be installed within the hood that disrupts the pattern and flow of air from the front of the hood to the back of the hood. Should it be necessary to do this, the greater the displacement of elements from the face of the hood to the back of the hood, the better the containment. In an excellent paper published in October, 1979 in the ASHRAE JOURNAL entitled *The Rating of Laboratory Hood* Performance, Fuller and Etchells defined problems associated with user proximity to the hood sash opening. This displacement backward from the hood face allows the flow disruptions to occur away from the hood sash opening as has been pointed other in the literature by several others. Moreover, the greater distance an emitter is setback into cavity of the hood away from the plane of the sash opening, the better the hood containment.

Exhaust Stack Enhancement: Maupins and Hitchings indicated that re-entry of contaminate air into the building they addressed was occurring. Their fix included increasing stack height and exhaust discharge velocities form the stack. As reentry occurs when the source of the emission is located such that it is picked up by the building supply air intake and violates the "..solution to pollution is dilution.." rule. Unfortunately, increasing stack discharge velocity does not guarantee that the emission from a building is dispersed into or above the air flow wake above or around a building and most often fixed associated with increased discharge stack velocity are not effective except for select equipment vendors. The ASHRAE ***Handbook of Fundamental*** addresses the re-entry problem and identifies source discharge away from intake as the only viable solution to this problem, which is best achieved with stack height and proper design.

IN CLOSING

We claim concern for IAQ in schools and the work place and we question what we are doing to our children with bad IAQ in schools. We are concerned with laws that regulate our outdoor air and water environments. Yet we have ignored and continue to ignore the sick laboratories with building codes and code revision violations. We budget retrofit cost before design and then force the design into the budget. In our selection of design professionals, we always want to hire an architect as prime professional, whose emphasis is aesthetics. Then we allow him to hire mechanical engineers at a lesser fee to worry about the ventilation aspects of laboratories. Since you still get what you pay for, what consistently suffers?

Fortunately because of the significant energy savings associated with constant fume hood face velocity, variable hood exhaust flow, savings opportunities now exist; deferred maintenance because of lack of funds is no longer an excuse and retrofit savings can pay for safety enhancement. Unfortunately many manufactures have entered this product market, especially since 1980, espousing use of defective systems and improper fixes. Also unfortunate is that some manufacturers have come and gone because of liability concerns and because they knew that their offering did not perform as required, implied or stated. It remains for the owner's safety professional and engineers to be truly conscientious regarding what is taking place with systems purchased: some have falsely implied and stated performance taunted, that are defective and when the defects are identified, corrective action should be taken immediately to fix the problem.

We are now beginning to recognize and own up to the fact that latent but brutally harmful carcinogenic materials exposure problems are turning up 5, 10, or more years to haunt laboratory personnel. With the technology and understanding of the problems we now have, there is no excuse for this. Students, our "brain trust" and future, are being subject to exposure everyday, especially in graduate and research situations. We cannot continue to expose innocent and unknowing individuals, especially to carcinogenic harm, and we cannot allow them to rely upon what some manufacturer has published, or on indicating devices that read incorrectly and display improper operating and face velocity data.

You, as campus safety professional, must challenge the goals, the methods, the design professionals, the design process, the commissioning, and maintenance if you truly want to maximize safety and ventilation containment in laboratories. **Laboratories can be made safer places to work!**