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Healthcare Engineering Controls

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One Sentence Summary: Healthcare engineering controls rely upon pressure relationships, directional airflow, dilution and filtration to improve indoor air quality and infection control.

Abstract: Hospital facilities rely upon several subtle engineering methods to control airborne infectious agents. Included in these methods are pressure relationships, directional airflow, dilution, and filtration. The commonality among these methods is that all are mechanically induced utilizing air-handling units (AHUs). The text describes typical systems that are used. The conclusions drawn are that indoor air quality is inextricably linked to mechanical system performance and that investigators (Industrial Hygienists) are well served to have a working knowledge of these systems. In summary, measurement of the performance of these systems requires a working knowledge of the facility to complement the industrial hygienist's experience with airborne toxins. Case examples of engineered systems and types of microscopic indoor toxins intended for control are provided.

INTRODUCTION

Both the toxins of concern and the methods of control occur simultaneously unseen by the caregiver, the patient, and the facility manager. The micro-toxins include fiber, ultrafine particulate, fume, vapor, spores and skin cells to name a few. These are undetectable to the naked eye and intended to be controlled by invisible air currents. This unseen nature makes the whole process difficult to understand and a challenge to measure. Yet, the performance of airflow engineering systems operating invisibly is crucial to air quality and the hospital infection control mission.

MATERIALS AND METHODS

Case studies involving five different regional hospitals with over 8 million square feet of floor space provided the insights for this manuscript. While mechanical systems and medical procedures were tested, a major limitation was that "No service interruptions" were permitted that interfered with patient care. This meant that testing was worked in and around patient needs eliminating the option to turn off systems and establish baselines.

In general, each facility implemented airflow controls using mechanical methods that depend upon AHU performance first. This allows the conditioned supply air to be further treated with a variety of secondary systems that include filtration or ultraviolet to name but two. At the terminal point, delivery of supply air is controlled by plenums and diffusers of different configurations that determine velocity and direction. Return air systems are equally important to the manipulation of direction, dilution and pressurization. Practitioners of HVAC design, performance and maintenance know that air is not infinitely compressible, so that in confined spaces the *volume in* must equal *volume out*. This is the fundamental idea that underpins a majority of velocity and directional airflow controls.

Every facility is different, but the result is that outdoor air must be effectively conditioned to service diverse medical procedures. Thus, mechanical system design and performance cannot be assumed.

Non-destructive test equipment includes particle counters, manometers, balometers, anemometers, infrared cameras, air pumps, bioaerosol cassettes, sorbent tubes and phase contrast microscopes. The performance of all of these common industrial hygiene tools should be certified by manufacturer's calibration, and then field performance checked prior to data collection. Sampling methods should be traceable to occupational health and facility engineering references from organizations such as NIOSH, OSHA, AIA, ASTM, AMMI and ASHRAE. An explanation of these acronyms is contained within the Reference Section citations.

RESULTS

Understanding the engineering systems and how they are intended to perform is of great assistance to the industrial hygienist testing indoor air quality. The unseen air patterns created by engineering controls are an integral part of the discussion of air sampling results. Measuring mechanical system performance in conjunction with air sampling provides insight into the appropriate selection of sample locations, collection techniques and later data interpretation. The requirements for this are contained in Association Standards that are adopted by hospitals as best work practice. This documentation is also part of the Joint Commission Accreditation inspection criteria.

DISCUSSION

Control of patient outcomes is increasingly emphasized in medical practice, particularly with the implementation of the Affordable Care Act of 2010. Knowledge of the environmental conditions, including indoor air quality, is one of the most important variables in evaluating not only the consumer's perception of facility cleanliness, but also the patient's well being. Consistently, surveys using the Hospital Consumer Assessment of Healthcare Providers Services (HCAPS) tool indicate "cleanliness" as one of the most important measure of hospital quality of care. Yet, this measure is subjective once you consider microscopic toxins. Elusive to measure, yet arguably the most important toxins to affect infection control, micro-toxins are pervasive in the realm of the visually unseen. Taken to its apparent conclusion, unseen toxins controlled by unseen engineering systems will likely be performance tested only intermittently, but measured daily by patient outcomes.

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