Walls and Ceilings - July 2011

Prescribing a New Hospital

Advances in medical technologies and practices have spurred new thinking about the construction of medical suites.

By Jon Mooney

A relatively inexpensive hobby of mine is the collecting of old technology books. My collection includes books on rebuilding player pianos, blacksmithing and a mail order course on how to set up a vacuum tube radio repair shop (I will be set if my time machine leaves me stranded in the 1850s or 1950s). One of my favorite books was written in 1870 and describes the technology of the day and includes a prediction of the U.S. and technology in 1970. Although the future world it describes is interesting (including mass transportation through giant wooden pneumatic tubes) the 100-year prediction was too far a stretch to extrapolate the technology of this period. Today's rate of technological advancement makes even a 10-year prediction questionable. Therefore, with that warning, I present the state of current hospital operating room technology and venture a prediction of the surgical suite in the year 2020.

Paging Dr. Difficult

If you have ever helped construct a surgical suite, you will agree it is one of the more complicated and most inspected project types. Most inspected because surgical suites must comply with Department of Health regulations and Facilities Guideline Institute design practices before they are approved for use. More complicated since simple building component designs cannot generally meet one performance requirement without compromising another.

Present surgical suite design is heavily influenced by the FGI which publishes "Guidelines for Design and Construction of Healthcare Facilities" once every four years. The FGI is a collaboration between the American Institute of Architects and the United States Department of Health & Human Services.

To reduce the opportunity for organism growth within the surgical suite, the FGI guideline requires surgical suite ceilings to be “monolithic” (a surface free of fissures, cracks and crevices). Today, this usually means hard, smooth surfaces of epoxy finished gypsum. Walls are typically ceramic tile or epoxy finished wallboard and floors are seamless sheet vinyl, linoleum or rubber. But, because completely hard room finishes result in a reverberant room, they add to the cacophony of mechanical and medical equipment noise and reduce the speech intelligibility within the room. To address this issue, surgical suites in Europe have begun using stretched plastic ceilings with fiberglass sound absorber panels placed above them. Noise passes easily through the stretched plastic ceiling where it is absorbed by the fiberglass panels. According to Pascal Gicquel, president of Newmat USA Ltd., “While Newmat (stretched PVC ceiling) would be perfect for this particular application because of its monolithic aspect, the fact that it can be sealed, the fact that it is washable and the fact that we have a specific membrane with a “bio-pruf” treatment (anti-bacterial), we have been unable to be specified and/or used for this type of application in the United States. I am not clear on the reasons for this failure, since we have done similar applications throughout Europe.”

Presently, washable and demountable sound absorption is allowed on the walls of a U.S. surgical suite. Robert Marshall, Technical Services Engineer for CertainTeed recommends Hygiene Advance Wall or Hygiene Foodtec Wall. “Essentially removable acoustic panels (for cleaning the panel and cleaning behind the panel) … provide excellent absorption.”

Turn Your Head and…

Ventilation is another important regulated requirement of surgical suites. The ventilation system is arranged so that air drops down from the ceiling directly above the operating table and travels outward. In the ideal case, every air molecule travels along an airstream directly from inlet to return, passing the operating table only once and spending only about two or three minutes in the room. But, since most surgical suites are not aerodynamic but rather rectangular rooms filled with obstructions, airstreams tend to break up into less than ideal patterns. Also, replacing all of the air in the room every two or three minutes results in noise created by air rushing in and out of ventilation grilles through ductwork and control dampers and by the fans that supply the air. At this high rate of ventilation, even air rushing out the bottom and sides of doors can cause noise issues. Present FGI guidelines recommend quiet operating rooms but also point out, “… current ventilation system technologies and devices required for sanitary purposes often result in sound levels higher than these.”

Also a function of ventilation is the control of room temperature. Preferred room temperature and temperature of air surrounding the patient depends on the type of operation and the needs of the surgeon. Surgeons and their staffs want to be cool because of gowning requirements and

the amount of time they are in the OR but the type of surgery will dictate conditions in the room. Cardio procedures typically cool the patient while pediatric procedures may require a warm-up cycle.

Better or Worse?

Lighting requirements are much more complicated than one might first suspect. Of course, the amount of light on the patient must be at least the required minimum. The amount of infrared light is kept at a minimum to prevent drying of tissue and localized heating of the room. The amount of light on room surfaces should not be less than one third of that on the patient. This is to prevent the surgeon's eyes from becoming fatigued as they periodically look up to monitor equipment. Surgeons may prefer certain colors of light for specific operations. A recent development is the replacement of incandescent surgical lights with focused LED lights.

When I asked KJWW Engineering's Senior Clinical Engineer, Tom Todro, what equipment should be included in our future surgical suite he replied, "You would want to include surgical robots and surgical navigation systems as well as video integration. Though not yet an industry standard term, the 'wall of knowledge' is gaining more interest. There are all kinds of data sources, alarms, patient data, etc., that are all discrete systems. The wall of knowledge seeks to integrate these systems displaying only the information that the surgeon needs and alarm information should conditions change from the normal operating range. The prevalence of surgical navigation and surgical robots is growing at a phenomenal rate. These systems allow the surgeon to view not only the actual patient but also a composite image from a CT (Cat Scan). The surgical robot is operated by the surgeon and both systems allow for truly minimal invasive surgery (smaller incision) which leads to faster recovery, reduced stress on the patient and reduced post-surgical complications from infection."

Steady as She Goes

Micro-vibrations in the floor and ceiling of the surgical suite, caused by mechanical equipment in a distant part of the building, can cause blurry images in high resolution medical equipment such as the surgical microscopes used in brain surgery. The classic solution is to mount the equipment on a massive concrete pad which sits on springs. However, as medical equipment becomes more sensitive, the pads must be designed heavier and the springs must be made longer. Presently, equipment sensitivities require spring lengths and pad weights which are becoming unwieldy in construction. A relatively new type of isolator which doesn't require excessive weight or spring lengths is the negative stiffness mechanism developed by Minus-K Technology. According to Jim McMahon, President of Zebra Communications and technical

spokesman for Minus K, “I do understand, with the increased use of sensitive optical instrumentation in the OR, it is inevitable that non-intrusive vibration isolation would be required. For quite some time, Negative-Stiffness Mechanism vibration isolation has been used in laboratory environments, including sensitive medical research applications, not only because of its superior capability of canceling out vibrations that can negatively influence operation of sensitive optical instrumentation, but also because of its non-dependency on electricity or pneumatic requirements, making NSM an ideal system for critical environments such as Class 100 operating rooms.”

Utterly New and Not so Different

Starting with today’s state of the art, we have developed a concept of the surgical suite of 2020. Gypsum board manufacturers and contractors will be happy to know the surgical suite of 2020 still has rectangular gypsum walls and ceilings. In most cases, it just is not feasible to fit non-rectangular rooms within a building envelope. To isolate the surgical suite from building vibrations and noise from adjacent spaces, the entire room floats on several NSMs. Beneath the gypsum ceiling is a stretched plastic ceiling, supported by tubular framing and given the shape of an isentropic expansion nozzle to encourage ventilation air to remain laminar. Sound absorption, as well as indirect room lighting, is hidden between the stretched plastic ceiling and the hard gypsum lid. Borrowing from James Dyson’s bladeless fan look, we have anticipated a major advance in ventilation design using concentric airfoil rings with separate injected flows and allowing detailed airflow and temperature adjustments with minimal noise.

Surgical lights have been taken off the ceiling and placed at the incision site. To make sure the room stays well sealed, entry doors are Tanaka-type automatic slat doors, each pair of slats opening only about 2 inches wider than the person or object passing through. To allow the room to be thoroughly disinfected without damaging medical electronics, the wall of knowledge is now a 3-D, holographic display with all of the electronics housed safely in a separate room. And although no-one else mentioned the need, I have seen enough operating rooms to know that a great sound system, preloaded with the surgeon’s music library will definitely be part of the surgical suite of 2020. Take a tour and listen to the 2020 surgical suite on my Web site www.jwmooney.com. (available August 2011).