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On the Agenda

Introduction: ACS would like to be a resource to your teams. In order to demonstrate our potential value, we would like to periodically send you an e-newsletter that provides information or food for thought. If you find these short introductory letters to be of any value, or you find something that is particularly relevant to a matter you are dealing with, we welcome your inquiry for a more in-depth discussion. Also, if you believe this information to be of value, please feel free to pass it on to a colleague.

So here is our first installment, not in any particular order, just something we thought you would find of interest.

Discussion – Why HVAC Systems Fail:

In this first installment, we'll identify and briefly discuss a few of the reasons why many HVAC systems either fail outright or give less than satisfactory performance.

The reasons may be technical, contractual or even simply a matter of perception. The failure may be relatively minor or catastrophic. Whatever the root cause of a real or perceived system failure, the matter may wind up in litigation or other situation that strains the relationship between the owner and the design/build team. Understanding the root causes may lead to better projects or at least better relationships between the parties that can help to avoid or minimize the damage caused by disputes.

While the issues addressed will be discussed from the perspective of HVAC systems, many of the reasons and the potential solutions, can be applied to other building construction systems – lessons learned here may have more universal application than first appears.

Here are a few of the reasons why HVAC (or other systems in the built environment) fail.

1. Owner criteria may be inadequate or inaccurate
2. Systems selection may be inappropriate
3. System operating loads are incorrectly estimated in magnitude & variability
4. Engineering calculations are inaccurate
5. Simple drafting errors not caught before construction

Owner criteria may be inadequate or inaccurate

Design of the HVAC systems begins with determination of the objectives of the owner. These objectives may range from simply creating a comfortable environment for the occupants (however that is construed) to controlling the environment for stringent technical reasons, most generally to enhance manufacturing processes. In creating this environment, the owner is almost always interested in achieving his goals for the HVAC systems at the lowest possible cost. Accordingly, the HVAC design and construction team must not only be cognizant of systems and design techniques that work effectively, but the cost implications of the many choices it will make during the design process.

The Owner's Role: While most people understand that the design process represents the collaboration of the professional architects, engineers and other consultants that work together to create the design and construction documents for a facility, we frequently overlook the role of the owner as an equally important member of the design, and later, the construction team. The owner is, after all the only party that can definitively state and then later judge what it is that he is trying to achieve. The owner in a properly executed design process is immersed in the details of the design and many of the decisions that go into the design. Architects and engineers will offer develop design alternatives that are based upon their experience on similar projects. These alternatives must be weighed by the owner's team to decide on the best solution for their project. In the end, the design must be approved by the owner prior to construction. While the owner is generally not expected to have the technical expertise of the design team, some owners (especially large organizations that regularly build facilities) are more experienced than others and often dictate design concepts or system choices that are to be incorporated into the project.

Whether represented by an experience facility engineering team, or a first time "buyer" of design services, the owner should understand from the outset that to a large extent the quality and success of the project will depend upon the decisions he makes (or doesn't make) and the attention to detail he pays to the design process. The design of a building or facility represents the development of purchasing specifications for that building, much like the process of deciding on what car to buy, the obvious difference being that the final product cannot be "test driven" until after the owner has already made the purchase. Nowhere in the purchasing process is the phrase "buyer beware" more relevant than in the purchase of a building or facility through the design process.

What Can an Owner Expect? The standard of care of a design or construction professional is not perfection, in spite of what many owners believe. A discussion of standard of care as it relates to the design and construction of HVAC systems is a lengthy topic that won't be addressed in this issue, but warrants careful consideration in any forensic or litigation consulting matter – what did the owner have the right to expect and did he get it?

Systems selection may be inappropriate

There are as many types of HVAC systems to choose from on a given project as there are combinations of owners, design firms and contractors. The development of an HVAC system design is truly a matter of system engineering. The owner states what he is trying to achieve and the design/build team evaluates the optimum means to achieve those goals given the constraints of time, budget, knowledge and a wide variety of other factors. The design/build team picks from a virtual "grab bag" of parts, materials and components and puts them together into a functioning HVAC system – thus, systems engineering.

The owner's goals are often conflicting in terms of initial budget constraints vs. the need to operate economically with minimal maintenance and simple, if any, ongoing user input. In addition, everyone expects these systems to operate satisfactorily day in and day out regardless of the outdoor weather conditions for many years.

In addition to having to create systems that are compatible with the owner's goals and budget, the HVAC design/build team must integrate their equipment and distribution systems within the architecture of the building. This systems integration effort is often one of the more challenging aspects of the design phase. As the architectural aesthetic goals and space allocation frequently constrain the engineering systems, especially in commercial projects, the engineer must be able to negotiate for the space required to ensure the systems and subsystems can be accommodated.

There are numerous factors that cause challenges and therefore potential failures of HVAC systems. The HVAC system is, of all the building systems the one that is most organic in nature, that is to say it acts much like a living organism, whereas the other building systems, such as structural, electrical and to a lesser extent, plumbing systems are static, or relatively static in nature. The HVAC systems in the building can be likened to the functions of the lungs, the digestive tract and the metabolic control systems of the human body. When one is out of sorts, the entire body may refuse to function properly.

The integration of a wide variety of components including fans, pumps, compressors, boilers, piping, valves, controls, and more, requires skill and expertise to ensure compatibly. The skill and experience of the design/build team, coupled with good communication of the owner's long term needs will dictate the wisdom of the systems selected.

System operating loads are incorrectly estimated in magnitude and variability

The evaluation of heating, cooling, humidification and dehumidification loads associated with an HVAC system design is often more involved than one might imagine. The sum of loads imposed by the local environment the building is exposed to, internal heat generation (lights, people and various equipment), and outside air introduced for ventilation must be handled by the heating, cooling, dehumidification and humidification equipment and the controls that orchestrate them on an ongoing and virtually instantaneous basis as they change throughout the day and during the seasons of the year.

If these loads are underestimated, the indoor design conditions cannot be met. If they are overestimated, the owner will pay too much for the systems and the components may not function properly at the actual reduced loads.

Even if the loads are properly estimated on a gross level (as in for the entire building) the distribution of the loads and therefore the distribution of the heating and cooling media (generally room supply air) may be improper - leading to hot and cold spots (or worse) throughout the building.

While the influence of external loads (air temperature, solar energy, moisture, etc.) can generally be reasonably evaluated given enough time and care, the loads inside the building are often difficult to quantify, especially in a high internal load application such as a laboratory, computer room, manufacturing operation and the like. These internal loads sometimes are far greater than the external loads we generally think about, thus the potential for a really significant disconnect between actual load and system capacity may exist.

Another frequently misjudged load element is that associated with outside air to replace exhaust or outside air required by the current crop of codes that have been promulgated as a result of “sick building syndrome”. Exhaust air must be replaced by outside air that has to be heated, cooled, dehumidified, humidified and filtered to render it suitable for use in the HVAC system. These loads sometimes overshadow all others and can be a significant source of system failure or poor performance.

This is a complex subject that requires careful forensic analysis if the dispute appears to be based upon improper system load analysis, as is often the case. In some circumstances, the inherent capacity of the systems may be adequate, but the controls or interrelationship between components may actually be at fault.

Engineering calculations are inaccurate

Garbage-in equals garbage-out. We’ve all heard this adage with respect to computer analyses or any engineering computation for that matter. This is just an abstract saying until it hits home on your client’s project.

The advent of more and more reliance by engineers, contractors, suppliers and vendors in the construction industry has the benefit of allowing more work to be accomplished more quickly and more options to be evaluated in the development of design solutions than ever before. Our computational capacity and available software also has the potential downside of providing false levels of assurance that because the computer spits out very precise appearing calculations and results that they are always reliable and accurate.

Over reliance on the computational machines and software at our disposal can result in design errors that aren’t caught until after the project is started-up and doesn’t work properly. The quality assurance process of the design/build team is supposed to catch this kind of error, but without “sanity checks” done by people with enough hands-on experience to spot an error by knowing that the results simply don’t look right, they can slip through the cracks of our often hurried and imperfect processes.

Simple drafting errors not caught before construction

Much like the garbage-in, garbage-out syndrome of engineering computations conducted with computers and their software, the bulk of all drafting of the documents used to describe what the engineer wants to the contractor, is accomplished with CADD systems.

While CADD has been a great benefit to the design/build industry, eliminating much of the drudgery of repetitious drafting operations, it is not a panacea. The quality assurance process still needs to be faithfully conducted by the most experienced personnel on the team. The expectation that because the drawings were prepared by computers using sophisticated software, they must be correct must be overcome.

Some errors are the result of using outdated files that are “XREF’d” (electronically referenced in as background information) into the drawing the HVAC engineer is working on. Other errors result from copying the wrong reference detail from a vast library of previous projects. Yet other errors are simple “typos” that get past the QA group and wind up dictating the design of a component incorrectly.

Whatever the cause of these simple and common errors, if not caught early enough, or if they are of a significant nature, the consequences can be devastating.