

Commissioning Hospital Construction

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Synopsis

Not only does hospital construction warrant the commissioning process, but it also requires commissioning of some systems unique to hospitals. Additionally, a hospital needs to provide for a healing environment. Because of this, such things as the need for increased natural types of lighting, reduction of noise, measures to ensure infection control, etc. are all critical to the design and operation of the facility. These requirements create a commissioning process that is different than any other type of commissioning project. The commissioning process should start at the design phase, continue through the construction phase, and finish with the start-up and verification of proper system operation. Additionally a periodical monitoring of the project's first year in operation and a near end of warranty review and report can be of significant value to the hospital's operational staff.

About the Author

Ken Toombs is the President and principal owner of Toombs & Associates Engineering Specialists, Inc., an engineering consulting firm that specializes in building commissioning. With offices in Denver, Colorado and Ann Arbor, Michigan, they perform commissioning work throughout the United States. Mr. Toombs is a graduate of Cal Poly San Luis Obispo where he obtained a Bachelor's of Science degree in Mechanical Engineering. Upon graduation, he spent four years as an officer in the United States Navy. Upon release from active duty, Ken spent approximately 15 years working in facilities operations, maintenance, and management. For the last 17 years, Mr. Toombs has been working as a consultant specializing in building commissioning. In 1995 he started the firm of Toombs & Associates Engineering Specialists, Inc.

The Need and Prevalence for Hospital Commissioning

It would seem pretty obvious that due to the critical nature of the functions that occur in a hospital, the commissioning of a new hospital or renovation of an existing facility would be warranted. It is this author's opinion that hospital owners have always considered that when a new facility is constructed or an existing facility is renovated, at the completion of the construction process they will have a fully functioning facility that meets the requirements and standards of its design. In the past the responsibility of ensuring systems were operational, as typical of most construction projects, was left to the contractor or construction manager and commissioning was not necessarily utilized. Over the past decade, as the commissioning of building systems has become a more common practice in the construction process, more and more hospital owners are starting to realize the advantages of having a formal commissioning process. Additionally, with the advent of LEED and GGHC commissioning has become more prevalent.

Hospital-Unique Requirements

Hospitals have unique functional requirements that are different from many other facilities. Hospitals, first and foremost, are facilities that are designed and built to provide for the care and healing of patients. Many, if not all, of the typical hospital building MEP systems are required to operate 24/7 throughout the year. Systems need to be designed to reduce and limit the possibility of infectious disease being transmitted from patient to patient and patient to staff. Operating rooms need to have their air flow designed to protect patients against infection and provide a comfortable working environment for the surgical team. Oxygen and vacuum needs to be provided to patient rooms. Oxygen, medical air, vacuum and other medical gases need to be provided to operating rooms. Imaging equipment needs to be installed and properly shielded. Security access systems are typically required. Communications systems such as paging and nurse call systems are required.

Many hospital systems require emergency power backup. Proper installation and testing of the emergency power system is critical for all hospitals. Additionally, life safety requirements are also critical for hospital operation.

Choosing Commissioning and the Commissioning Provider

It is critical that in the planning stage of a project the hospital determine whether or not they wish to have commissioning performed on the project. Many hospitals are becoming aware of and embracing sustainability issues. Because of this a LEED or GGHC certification is now becoming more desirable to many hospitals. Both of these programs as well as the AIA Guidelines for Design and Construction of Health Care facilities recommend some level of building commissioning. One of the keys to getting the most out of the commissioning process is to start the process during the design phase of the project. Design architects need to discuss commissioning with their clients during the programming phase of the project, so if the owner elects to have commissioning, the

commissioning provider can be selected and become part of the project team prior to the completion of the schematic design.

In selecting a commissioning provider, the hospital should solicit a request for qualifications from qualified commissioning providers. Based on a review of the responses to qualifications and interviews of the top three to five firms the hospital should select their preferred provider. Once the provider has been selected based on qualifications, a finalized scope of work and fee should be negotiated between the hospital and provider.

Commissioning Process

Design Phase

It is critical that the commissioning process include design reviews at the 100% schematic design submittal; at the 100% design development submittal; and the 60% and 95% construction drawing submittals. Additionally the commissioning provider needs to develop commissioning specifications that will complement and be incorporated into the final construction project specifications.

The commissioning specifications should clearly delineate the commissioning responsibilities of the commissioning provider, owner, design team, construction manager/general contractor and sub-contractors. It is important that the specifications clearly specify the process of special systems commissioning.

Design reviews should be focused on compliance with AIA Guidelines for Health Care Facilities and ASHRAE standards. Additionally, local guidelines including specific State requirements are typically required for hospital construction. Since some of these standards are different, it is critical that the commissioning provider bring to the hospital's attention the differences and an appropriate choice by the design team and owner is agreed upon. Additionally, the commissioning provider should educate themselves on their client's own design standards, if any, so that they can ensure that these standards are being met.

Additionally, design reviews should be focused on how well systems can be maintained and operated over the lifetime of the facility. Based on the scope of work negotiated with the client, the design review could also include energy modeling and equipment life cycle analysis.

Hospital overhead space is always a critical issue. In reviewing the design the commissioning provider must ensure that enough above ceiling space is being provided. Typically the floor to ceiling height desired by the architect is 9 feet. Keep in mind the AIA guideline standard is 7' 10" with a requirement of 9' for seclusion treatment rooms. Obviously the higher ceiling height provides a more aesthetic look, but the amount of ductwork, medical gas piping, fire sprinkler piping, hot water or steam piping, chilled

water piping, domestic water piping, plumbing piping, conduit, lighting, and IT cabling that may be required to be concealed in the ceiling makes space a critical issue. Ensuring proper ceiling space in the design phase will assist in the construction and future maintenance of the completed systems. This is easily said but always difficult to achieve.

The commissioning provider needs to be concerned with future accessibility for the operations staff as they review the design. One issue that often comes up is the location and accessibility of fire dampers and smoke dampers. With regards to smoke dampers, if there is not an integrated smoke control system these dampers are not required to be monitored by the fire alarm system. Therefore, often they are installed without any means of locating them other than their location on a construction document. It is recommended that if this is the situation, the commissioning provider should strongly recommend to the owner and design team that these dampers be provided with a damper position switch and associated ceiling tile LED light. This will allow for the operating staff to easily find the location of the damper and identify its position in the future.

The issue of outside air and the control of how minimum requirements are being maintained are extremely critical in hospital construction. It is recommended that minimum outside air dampers with proper air flow stations be utilized to ensure proper outside air requirements.

One of the critical criteria of hospital design regarding air flow centers on the number of air changes. As more and more VAV systems are being utilized in hospital design it is critical that minimum air flows and diversity in fan sizing be carefully reviewed to ensure proper air flow.

In the design of isolation rooms and protective environment spaces pressurization is typically based on air flow offsets between supply and exhaust air. In isolation rooms exhaust is greater than the supply and vice versa with regard to protective environment rooms. The commissioning provider should ensure with their design review that there are proper specifications of how these rooms will be sealed. They should caution the design team and owner that without proper sealing of spaces, typical design offsets will have to be larger than design to ensure proper pressure differential.

Sound and its attenuation is also a critical issue in hospitals. Unfortunately this is a very difficult issue to remedy if not properly designed. The commissioning provider should review the design with regards to noise levels and what is being designed into the system to keep sound levels tolerable. It is strongly recommended that the design team engage a sound consultant as part of their design team. If one is not already on the design team it is suggested that you make this recommendation to your client. Patient rooms, treatment rooms, exam rooms, and operating rooms are typically the most critical areas for noise. Often the design of the ductwork can eliminate the use of attenuators at terminal units. Since the use of attenuators has an affect on system static pressure, getting it right in the design phase is critical from an owners cost standpoint.

Based on past experience, a critical issue that is sometimes missed in design review is an analysis of how well architectural, structural, mechanical, plumbing and electrical drawings are coordinated. Since commissioning primarily focuses on the MEP systems, often times the commissioning provider neglects to review the other documentation for proper coordination. Past experience has shown that this is a critical review item that should be done, if for no other reason to ensure that shaft and riser spaces have been properly coordinated.

The coordination of medical equipment with regards to location and requirements for building plumbing and electrical services is another area that requires attention. Typically a medical equipment consultant is hired by the architect or owner to assist in the selection and location of permanent and movable medical equipment. Much of the fixed medical equipment is typically installed by the vendor with services being required by the construction contractor. Some equipment such as x-ray equipment will also require special shielding and certification at the completion of the construction process.

Of major concern is the change in medical equipment building services requirements from the time the project is first designed to when the equipment is purchased and installed. The coordination of building services typically occurs fairly early on in the development of construction documents. This is coordinated by the architect with the medical equipment consultant and design engineer and should result in medical equipment drawings. Based on this documentation the design engineers provide MEP services on their drawings to reflect the service necessary to comply with the medical equipment drawings. However, what often occurs is that as the project progresses the hospital staff talks with the medical equipment consultant and equipment locations and type change. Additionally, often by the time the equipment is ordered, the original specified model has now been replaced by a newer model that often requires a change in services or service location. Although this monitoring of changes in medical equipment may not specifically be a commissioning provider's responsibility, being aware of the aforementioned situation and prompting the owner and design team to continually update and revise this data during the design and construction phases can save many headaches and the owner from some possible change orders.

Another source of a possible problem that can be identified in the design phase may occur with regard to special systems. These may include security, paging, clock, nurse call, etc. Often, both the architect and engineer don't have a great deal of expertise regarding these systems. Additionally, the hospital may have specific manufacturers they prefer to use. This may result in construction documents indicating that the system is to be owner furnished with some basic service such as the running of conduit, power supply etc. being supplied by the contractor. If not closely monitored and coordinated by the owner this can result in problems between the system supplier and contractor during the construction phase. Once again, although this is not necessarily a commissioning provider's responsibility, monitoring these issues for the owner can help reduce possible conflicts that could lead to change orders for the owner.

The commissioning provider needs to be aware of the critical need for infectious control procedures during any hospital construction project. This is especially critical in remodels, renovation, or addition projects. In the design phase an Infectious Control Risk Assessment should be performed on the proposed construction to identify what steps will be required to insure proper infectious control procedures are specified. The assessment should be performed by a team headed by the hospital and include members of the design team. These procedures will also have to be clearly reviewed with the contractor once they are selected and onboard. This assessment and the recommended procedures will then need to be reviewed and updated as required throughout the construction and commissioning phases of the project. The commissioning provider needs to be aware of the recommended procedures so that they can assist in monitoring that they are being followed and documented throughout the construction and commissioning phases of the project.

Electrical systems and their emergency power backup are major issues with hospital design. Some design engineers and hospitals may prefer the option of utilizing isolated power systems in critical care areas. These are not required by current codes but some design engineers and hospitals might utilize this system as an additional measure of safety. In wet locations the code does require an isolated system for receptacles and fixed equipment requiring uninterrupted power. Isolated systems will require specific installation requirements including an isolation monitor and specific tests prior to use by the hospital.

In summary, the design phase of a hospital project is the phase where the commissioning provider can assist the owner and design team in staving off future construction and operational problems.

Construction Phase

As a contractor is selected and construction starts the commissioning provider needs to finalize their commissioning plan and have an initial commissioning meeting. Hopefully the commissioning provider has been involved in the design phase of the project so the approach and contractor requirements have been well documented in the construction specifications. If the commissioning provider has not been involved in the design phase and construction is underway it is assumed that prior to finalizing their contract the provider has reviewed the construction documents so they have a good knowledge of the design and what if any commissioning specifications have been provided.

Prior to meeting with the contractor, the commissioning provider should review with the owner their proposed commissioning approach. This should be provided in the commissioning plan and provided to the owner. If not involved during the design phase, the commissioning provider will need to thoroughly discuss their proposed approach with the owner. In these discussions they will need to clearly explain their process and contractor responsibilities. This includes appraising the owner of any possible ramifications their approach may have in regards to contractor change orders. This is always a possibility if commissioning and contractor responsibilities have not been

delineated in the construction documents. Once the owner and provider have reviewed and agreed on their proposed approach and the owner has reviewed the commissioning plan, the provider should chair the initial commissioning meeting.

Prior to the meeting, it is recommended that the design team, construction manager/general contractor and sub-contractors be provided with a copy of the commissioning plan. During the initial commissioning meeting the provider should review the commissioning process. The provider should clearly state the expectations of the process. Key members of the commissioning team should be identified. The format and process of lines of communication should also be identified during this meeting. Some key issues that need to be identified are the process of how the required construction submittals are going to be sent to the commissioning provider and how they are going to be kept aware of RFIs. Fortunately, on many larger hospital jobs, web-based project management systems are now being utilized. These programs are very helpful as most correspondence; RFIs, submittals transmittals, etc. are readily available to the commissioning provider. Tentative commissioning meeting schedules should also be discussed in the initial meeting. Depending on the client and size of the project these meetings may be separate meetings or be included with owner, design team, and contractor progress meetings. If a separate commissioning meeting is to be held, it is critical that the owner have a project manager or project engineer at each meeting.

The review of submittals is a very important task in the construction phase. Just getting these submittals in a timely manner sometimes is difficult. If a web-based project management system is being used the commissioning provider should at least be able to quickly identify when submittals have been sent to the design team. It is strongly recommended that the commissioning provider be sent submittals by the contractor simultaneously as they are submitted to the design team. The commissioning provider needs to provide review comments in a timely manner to the owner and design team. The design team should review the commissioning provider's comments and then provide a copy of the approved submittal comments to the commissioning provider simultaneously as they send them to the contractor. Review of the temperature control submittal is a critical issue in hospitals.

As stated earlier an initial Infectious Control Risk Assessment needs to be performed. This is especially necessary if the project is a remodel, renovation, addition to a hospital and/or a new facility separate, but in close proximity to an operating hospital. Typically this assessment is the responsibility of the hospital and contractor, but in reality it is everyone's responsibility. It is recommended that the commissioning provider minimally participate in reviewing the assessment if not in fact participating in the assessment itself. Key issues that need review in the assessment include how the construction may affect the hospital air quality, disruption to utilities, infectious control, noise, vibration, life safety egress, etc.

In hospital construction involving the construction in or around an existing facility, it is critical that the contractors are aware of the function, connections and routes of the hospital's utilities. In this environment the inadvertent disruption of power, water,

medical gases, oxygen and vacuum may actually cost a patient their life. Therefore it is critical that all on the construction team are educated and vigilant in the area of utility disruption. This should include procedures concerning the proper notification and scheduling of the planned outage or interruption with the hospital's staff. Additionally, procedures need to be in place to notify hospital staff should an inadvertent disruption occur.

For hospital construction proper installation, cleanliness, and accessibility are three of the most critical issues. As with any construction project, ensuring the installation is in compliance with the construction documents is of prime concern to the commissioning provider as they perform periodic construction observations. The commissioning provider needs to have a good working knowledge of what is included in the construction documents with regards to specifications, means and methods and codes referenced in the specification. A good working knowledge of ASHRAE, SMACNA, and NFPA 99 is very helpful.

As construction is under way the cleanliness of staged and installed equipment is critical to prevent future contamination and possible growth of fungi or bacteria. All piping should be capped when staged and when installed but the system not completed. The same is true with ductwork. Ductwork when staged should be properly protected from the elements and when installed, open sections covered. Ideally duct work should be wiped cleaned prior to its installation. Sheetrock should not be allowed to become wet during its installation. If staged or installed sheetrock becomes wet and can't be dried thoroughly in 72 hours it should be replaced.

Indoor air quality to control infections is also very critical in hospital renovations, remodels and additions. From a careful assessment, plans need to be developed so that when required proper barriers, temporary exhaust, monitoring, etc. will be implemented and monitored. Dust control, proper air differential pressure, tacky mats, final cleaning, etc., are all critical items to be considered. A good reference to assist in developing individual plans and guidelines can be found in CDC's Guidelines for Environmental Infection Control in Health-Care facilities.

The generation of dust whether it comes from the outside due to new construction in the near vicinity of the hospital, or if caused from an internal construction or renovation, needs to be assessed. Dust from installation needs to be controlled and construction dirt and debris cleaned up on a daily basis. The hospital should have an Infection Control Risk Assessment performed. The assessment will determine what affect the construction will have on the hospital. Based on the type of construction and where it is occurring with respect to hospital operations will determine what types of precaution measures will be required. These precautions can vary from changing outdoor air filters more often and sealing outside doors to erecting barriers between spaces and providing a negative pressure in the space with HEPA equipped air filtration units. Typically a matrix utilizing the construction type, patient risk and class of precaution is utilized to determine what precautions should be utilized.

All medical gas system installation needs to be monitored for proper installation and support. The NFPA is very specific regarding the qualifications of those installing the systems as well as how the system is to be constructed, supported, and labeled. The code is also very specific with regards to when and how systems are to be tested and then finally certified. On large construction projects when large storage tank(s) are to be provided for oxygen storage, the tank storage installation is often provided by the vendor supplying the oxygen. The tank installation and the coordination of the tie into the piping provided by the contractor are often not clearly defined in the construction documents. The commissioning provider should be aware of this and may be required to assist in the coordination of this tie in between the tank and internal piping system. The commissioning provider may be called upon to provide for the certification of the medical gas systems. If this is required they will need to contract with an approved certifying agency. Whether or not the certifier is under the commissioning provider's contract, the provider will still need to work closely with the certifier.

The commissioning provider should provide the sub-contractors with pre-function test check sheets for their use in documenting and certifying they have completed their installation. These sheets should be developed by the commissioning provider after a review of the submittals. The timely completion and submission of these sheets is often a form of documentation that the sub-contractors are not interested in providing. In reality this is a critical management tool for the construction manager/general contractor and owner. It is recommended that completion of these forms be closely tracked by the commissioning provider and their importance continually reinforced to the CM/GC and their sub-contractors.

The actual number of site visits for construction observation should be determined based on a review with the owner. Minimally it is recommended that they occur at least monthly and on larger projects when construction of major MEP systems is in full swing, can typically be every other week. As systems are started and the balancing begins on site observation typically will be on a weekly basis. Each site visit should be documented with a field report and discrepancy/recommendation log. These logs should be reviewed in the commissioning meetings during each site visit so that they can be updated and issues identified can be resolved.

Post Construction

As construction is completed systems need to be verified as being functionally complete and ready for use. This requires the functional testing of all systems. The testing of HVAC systems should not occur until the balancing sub-contractor has completed their work and the commissioning provider has spot checked minimally 5%-10% of the balancing work. Additionally all control programming and calibration should have been completed prior to the balancing. Once the controls installation, calibration, and programming has been completed; the system's balancing complete and verified by a spot check by the commissioning provider, the functional testing can be started. In hospital commissioning critical issues regarding HVAC systems include verification of proper air changes; proper pressurization, proper smoke evacuation, and proper operation

in emergency power situations. The most critical areas are operating rooms and the surgery suite, isolation rooms and protective environment areas. It is critical that the air changes and pressure differentials be verified. Additionally systems utilized to monitor and alarm pressurization need to be verified. Since most designs typically utilize an air flow off-set for pressurization it is critical that spaces have been properly sealed. If not properly sealed, additional increases in off-sets are typically required to provide proper differentials. Modifying air flows away from the design can result in increased energy costs and may require fan or motor changes. All terminal units need to be tested by the commissioning provider rather than a random testing of terminal units. Anesthesia waste gas systems need to be tested.

Testing of the emergency power system is critical. The commissioning provider needs to ensure proper load bank testing of emergency generators. This also includes the testing of all generator fuel oil transfer systems, alarms, etc. All equipment and systems on emergency power, all lighting on emergency power and all electrical outlets on emergency power need to be tested for operation in an emergency power situation by the commissioning provider. Operation of ATS switches in a timely manner must be verified. Any sequencing of generators based on load needs to be tested. Any load shedding capabilities of the system need to be verified. Additionally proper wiring of systems needs to be verified to ensure that life safety equipment is fed from the life safety ATS and critical care equipment feed from the critical care ATS etc.

The facilities grounding systems need to be tested and if isolated systems have been utilized these systems need to be tested. Elevator operation needs to be certified for general and emergency operation.

Certification of the medical gas systems is critical. The testing of proper medical gas systems needs to be performed by a qualified contractor. The commissioning provider needs to coordinate the testing of systems with the installer, gas supplier and certifier. Additionally the testing of medical air compressors and vacuum pumps needs to be coordinated by the commissioning provider with the manufactures representative. All BAS monitoring of these systems also require monitoring.

Proper testing and certification of domestic hot and cold water as well as any special water systems such as reverse osmosis for research or dialysis needs to be performed.

The proper operation of nurse call systems, paging systems, and clock systems need to be verified as operational. The commissioning provider needs to supervise this testing typically performed and certified by the vendor. Any access control or security system additionally needs to be tested and verified by the commissioning provider.

The fire alarm system needs to be tested. This testing is typically done by the local fire authority. However this testing can be very complex as the sequencing of this system with the paging system, smoke control, security, air handling systems, and elevator recall etc., needs to be verified by the commissioning provider. Additionally the noise of alarms can be a critical issue in patient areas.

Proper operation of the hospital's fire suppression systems also needs to have its testing documented. Typically insurance companies get involved in this testing.

The testing of all major facility equipment and its proper control by a building automation system needs to be performed by the commissioning provider.

Ideally it is recommended that the commissioning provider coordinate the training of the facilities operation staff after all operation and maintenance manuals have been submitted and approved. The O&M manuals need to be specific to the exact type and model of the equipment installed. Additionally, it is recommended that the commissioning provider prepare or assist the facility's operation staff in developing a preventative maintenance program for the facility equipment.

After the facility has been in operation, it is recommended that the commissioning provider provide a near end of warranty review. This should consist of an on-site review of systems operations with the owner and their facility operator. This review should include a written report noting any warranty issues that need to be addressed and/or any other outstanding issues.

Summary

In summary it is felt that hospitals are facilities that truly can benefit from and require commissioning. The steps of performing commissioning on hospitals are no different from any other facility, while the systems in them may be different and more complex. As with all projects, the involvement of a commissioning provider as early as possible in the design phase of the project will make for a smoother commissioning process.