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THE COMMISSIONING PROCESS: HOW IT AFFECTS THE BUILDING OWNER AND MAINTENANCE CONTRACTOR

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ABSTRACT

The purpose of this paper is to discuss the effects of the commissioning process on the long-term operations and maintenance of heating, ventilating, and air-conditioning systems in buildings.

It will be shown that if all the parties to the commissioning process are effective in delivering a fully commissioned facility, the building owner will have long-term economical building operation and satisfied tenants, which will enhance the rental and/or occupation of the facility.

The development of a commissioning plan must be in place to allow the commissioning process to happen. While there is an initial capital investment for this process, if it is properly studied from a life-cycle basis it is our belief that this investment will be recovered over the life of the building. If a case cannot be made for this life-cycle cost recovery, it is our opinion that the commissioning plan must be revised to make the proper economic decision.

The commissioning process as a distinct part of the design, construction, and operation of buildings is a relatively new concept to ASHRAE as well as to designers and building owners. While owners always expected to receive fully commissioned facilities, this was not often the case, as the pertinent commissioning parameters were not defined at the design stage and of course would not be included in the construction phase.

We will explore this process from the point of view of operation and maintenance management, which includes in-house and contracted maintenance and operation of building HVAC&R systems. In the commissioning process the impact is felt last by the operations and maintenance staff and management; therefore, this paper will attempt to summarize the information that this group requires to allow the commissioning process to be completed successfully. At the final acceptance of a new or redesigned facility, the owner's operations and maintenance staff assumes the HVAC&R systems will function over many years in a comfortable, energy-efficient, and cost-effective manner. This can only happen if the facility is well designed, installed, tested, and had all systems balanced, and controls set up, in other words commissioned. The ability of the operations and maintenance

staff to effectively run the HVAC&R systems is directly related to the commissioning process.

In this paper we would like to discuss the timing of the involvement of the operations and maintenance management in the building design, construction, start-up, test and balance, and control fit-up. We would propose that the operations and maintenance management and staff should have involvement in all these stages so the final product can be maintained both cost effectively and with tenant comfort in mind.

The commissioning process has first-cost or capital cost implications. We will not attempt to quantify these costs, as they can be variable depending on the size and complexity of the facility being built. However, one must consider the owning and operating costs of a building in addition to the first cost or capital cost to be ensured of a life-cycle benefit to the owner. Unfortunately, the operations and maintenance costs associated with building ownership are lost when the original bids are received and the project is over budget. It is strongly recommended that the design, construction, and operations and maintenance management staffs of larger builders discuss the issues that affect life-cycle costs to be sure that economic decisions made at the design or construction phase of a project do not adversely affect the future operation costs or maintenance of these systems.

We would now like to discuss commissioning from the owner/operator and/or maintenance contractor's requirements in a more detailed manner with the emphasis on design, construction, test and balance, control, fitup, and acceptance documentation.

DESIGN

The design of HVAC&R systems can range from very simple to extremely complicated, depending on the requirements of each facility. We will discuss the more complex systems, as they require the most detailed commissioning planning; however, do not forget that these plans apply to all systems.

At the design stage of any project, budget capital costs are considered. We recommend that life-cycle costing be con-

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sidered to allow all parties to determine the value of trade-offs that may be necessary to bring a project into first-cost budget. Information in ASHRAE (1991) and Dohrman and Alereza (1986) ascertains the maintenance costs for various system types. An energy budget should also be determined to allow the designer to make informed decisions for the building owner. With all of the above information, the designer can determine if a properly commissioned system will meet life-cycle expectations. As the information on the impact of poor maintenance on equipment life and energy consumption has had little research, it will be up to the designer's experience to determine the life-cycle cost penalty as a result of not commissioning the systems on long-term adequate operation and maintenance of these systems. If the building operations and maintenance management are involved at this stage of the design, they usually can give the designer significant information to assist in making the economic judgement referred to here.

We would emphasize that the operations and maintenance personnel will not be criticizing the design capability of the consultant but rather discussing the impact of the design chosen by the consultant on the future operations and maintenance of this system. With this in mind, we present these requirements.

- The input from the operations and maintenance personnel can give the designer information on the occupants' needs in the facility being planned, as they will have knowledge of the future of the building that may not be apparent to the designer. This information will give the design team the requirements that are critical and where proper design trade-offs can be made to arrive at the most economical building design.
- The design team should discuss such items as the required complexity of the controls and systems to meet the comfort and energy efficiency of these systems. One item in this area that is often not addressed is the fact that these systems will operate at part load most of the time. An effective operations staff can give its experience in this to the designer. The selection of equipment and systems must address the part-load performance of the facility. This approach may affect capital cost but we return to the importance of life-cycle budgeting.
- Equipment location and access is critical for proper maintenance. While this seems self evident, it is often overlooked. Equipment selection is also very important as it will not operate fully loaded as referred to before; therefore, it may be necessary to select different units to allow long-term efficiency.
- The designer should consider the accessibility of parts from local suppliers for ongoing system support and maintenance. While this may appear to be a minor problem at the design stage, the long-term problems associated with lack of replacement parts or difficult deliveries can have a very high cost due to outages that tenants will not accept.
- The designer should be in agreement with the operations and maintenance personnel as to detailed information for the future operation of these systems to allow changes as occupants' needs vary. This information should be clearly detailed in the design documentation. The changes could be as simple as office relocations or as complicated as completely new tenants with different load requirements.
- Finally, the designer must inform the operations and maintenance management as to the skill level of the staffing to allow the systems designed to be operated by this staff. We cannot underestimate that the less complicated the design, the better chance we have of making a successful building in addressing such issues as good indoor air quality, comfort, and operations and maintenance costs.

CONSTRUCTION

At the bid stage of every project it often happens that the project may be over budget and it seems that the mechanical and electrical systems are viewed as the most expendable when cost reduction is proposed. If this happens, it can have a major impact on the commissioning plans that were laid in the design stage. Caution should be exercised when these cost reduction measures are considered as to their impact on the life-cycle costs of the facility.

When shop drawings and operations and maintenance submissions are made, the operations and maintenance personnel should have an opportunity to review these documents as to their adequacy for the facility. If the building owner is considering using an outside maintenance contractor, it would be appropriate at this stage of the project to request information to allow preparation of adequate maintenance procedures for the equipment or systems to be contracted.

The commissioning team must be involved in the construction process to be assured that the systems can be commissioned according to the plan that has been developed at the design stage of the project. Any deviation from the commissioning plan caused by construction change orders must be incorporated into the commissioning plan. For information on the commissioning planning, refer to the *ASHRAE Commissioning Guide* (ASHRAE 1989). This guide gives a planning method for HVAC&R systems but may be used as a basis for commissioning any building system.

During the actual construction phase of the project, the operations and maintenance management should attend the site meetings, observe installation of all major equipment to be assured accessibility for maintenance, and be involved in change notices that may affect future operation and maintenance of the installed systems. The operations personnel should attend start up of all major components and systems.

As members of the commissioning team in accepting a commissioned building from a commissioning agent, the operations and maintenance management must be informed by the constructor as to changes from the design drawings

and documents that will affect the life-cycle operation of these systems. We cannot overemphasize this point to allow a fully commissioned building that the owner expects and deserves.

TESTING, BALANCING, AND CONTROLS

The testing and balancing contractor has a major responsibility in the commissioning process as he or she takes on the task of making the systems perform to meet maximum flow but further to ensure that these systems will be able to perform at part load or be able to be adjusted to these common conditions. To be assured that the TAB contractor has proper qualifications to perform the balancing of the building systems, it would be appropriate to use a TAB contractor who has been certified by one of the balancing associations. Further, all instrumentation should be calibrated for the project and this calibration must be updated as required by the particular instruments. The calibration information must be part of the commissioning documentation. The commissioning agent should spot check the balancing information to assure the operations and maintenance management personnel that the reports are accurate, particularly at part-load conditions. The building occupancy, weather conditions, and time of year need to be a part of this report, as the balancing is normally done at a definite time. To completely commission a building system will normally require four seasons to determine the adequacy of these systems for ongoing building operations over the life cycle.

It would be appropriate for the operations and maintenance personnel to observe the balancing as it is being performed to give this staff the information that is to be determined from the balancing report. This observation will also give the staff the ability to understand the effect of making future system changes and their possible implications for the other parts of these systems. The observation will also show the operations and maintenance staff the required instrumentation to properly balance the systems in their particular building.

At the end of the TAB, this contractor must submit the proper reports to give the operations and maintenance personnel a permanent record of the balancing status of all systems at building acceptance so future changes can be made from a known baseline. ASHRAE (1989) shows the required documentation to complete this report.

The controls contractor has a similar responsibility to that of the TAB contractor. As each system is put into operation, the controls contractor should be working with the operations and maintenance staff so they can become familiar with the abilities and limitations of the control systems particularly at part-load performance.

The control information must be job specific to allow the building operator to make adjustments to the systems after the project is completed to give proper control without negatively affecting the thermal and energy consumption of the building. To accomplish this task, the control documentation

should be written for the capability of the facility operations staff. Providing general catalog cuts is not adequate for a fully commissioned building. The written information must be site specific so the operations staff will be able to make appropriate control changes without outside assistance, as it will be necessary to make adjustments to the control systems to satisfy tenants as the building is fitted up. These control changes may be required on a frequency as often as hourly so the operations staff must know how to properly do the necessary procedures for their building.

The final report of the controls contractor should include flow charts and methods of making appropriate control changes, particularly with direct digital control systems. With DDC systems, the owner, operator, or contractor must have information as to appropriate methods for making system adjustments and determining the building changes affected by these adjustments.

DOCUMENTATION AND TRAINING

To finalize the commissioning process it is necessary to turn over to the operations and maintenance management at least the following information to consider that the facility has been commissioned:

- as-built drawings,
- balancing reports,
- flow charts,
- operations information,
- maintenance information,
- control strategy,
- design intent and limitations, and
- part-load operation information.

With this information, future building occupancy changes can be done with the confidence that these changes can be incorporated and the information on the building will always be up to date.

In addition to supplying the appropriate documentation for the building, it is necessary to provide formal training of the building operations staff, maintenance staff, and outside contractors to allow them to use this information. The amount and degree of training will be commensurate with the complexity of the facility that has been commissioned and should be a part of the original commissioning plan.

This documentation and training is invaluable to future design changes or problem solving that may be required if the building is experiencing operational, energy, or occupant problems associated with the HVAC&R systems. With the baseline of information it is always easier for the operations and maintenance staff, outside contractors, or consultants to use these data to find solutions to the problems being experienced.

CONCLUSION

One can see that commissioning is a complex process. It has been assumed by building owners that they will receive a fully commissioned building under traditional contracts, but there is a great variance in the quality of this process. We should be happy that ASHRAE GPC-1 has produced a commissioning guideline that can give a basis of consistency for these procedures.

Our technical committee is currently responsible for working with GPC-4P to develop a guideline for operations and maintenance documentation that will assist designers and manufacturers in writing better manuals to improve the commissioning process. This will lead to improved operation and maintenance of buildings to reduce energy consumption and improve indoor air quality and tenant comfort.

REFERENCES

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