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MEP Design and Execution Assurance Services

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INTRODUCTION

There are many ways a mechanical, electrical and plumbing (MEP) consulting engineering firm can provide value. One area that many building owners and building users (tenants) don't always see the value of includes MEP site services. These include assessing existing site conditions, observing MEP construction, and assuring HVAC, plumbing and electrical system operation and performance.

Services such as these are found more often on large institutional or commercial projects where it is perceived there is a higher need for engineering involvement. While we would agree that a hospital needs a certain level of concern beyond what a small retail space would need, it is also true that it doesn't take much of a mistake to create huge liabilities and/or additional costs. It only takes shortcutting of codes, failing to follow standards, or shoddy workmanship to result in costly and potentially catastrophic problems.

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MEP consultants can provide site services that save building users construction costs, reduce operational facility headaches, and avert problems that could potentially cost millions of dollars to correct. These site services include:

Site assessments

- Feasibility assessment with report (prior to acquisition or lease)
- Preconstruction site assessment
    - o Site survey with report
    - o Post-demolition site survey with report

Construction administration services

- Site observation with report
- Below-slab observation with report
- Interim (rough-in) site visit and observation with report
- Substantial completion assessment with report
    - o Punch list site visit with report
    - o Final site review with report

Post-construction

- Functional performance testing
    - o Commissioning
    - o System validation

Each of these services has associated costs, but the potential for savings over the life of the MEP systems often more than justifies the costs incurred. In the following sections, each of these services are described in more detail along with the benefits gained by including them in the project.

Site assessments

The more you can know about your potential project site and its surrounding environment and constraints, the more you can reduce the potential for unforeseen obstacles that can increase project costs.

Architects, engineers, contractors and building users all look at spaces differently, yet collectively their common goal is to have a successful project. It is our goal to help all project stakeholders understand the benefits of engaging MEP engineering professionals for pre-lease, predesign and preconstruction site services. Our survey teams include professional engineers, design engineers, and trained field inspection staff. These services, when conducted by professional personnel, and when coupled with open communication between design team members, provide a greater opportunity for a successful project.

Often, due to the pressure of opening on schedule, these issues are put off or addressed in the field in a makeshift manner that is neither safe nor visually appealing. When issues are identified by the design team at an early stage, either during a survey or during construction, they can be addressed and a remedy can be discussed among the stakeholders and design team to the satisfaction of all.

Although these MEP services are often seen as added expenses, they provide significant value including reducing change orders, preventing schedule delays, and avoiding unwanted long-term operational issues that can arise through improperly installed systems.

A site assessment is a survey or qualified review of a building space. Site assessments can be performed at potential building sites, existing buildings and spaces within them, and at operational facilities.

A site assessment will help determine:

- The extent of the project, whether as a separate building, space or area within an existing building (where it is, how big it is, what borders it)
- If there are any physical obstacles that can affect design and cost
- Whether a potential building or space can meet the project requirements
- The scope of work required to prepare the space for the intended use and whether that will be within the proposed budget

Without an initial site assessment there may be missed opportunities to fully understand the site during the preconstruction phase of the project. Information that is unknown and not considered during the original design process can lead to significant additional services from the design team and change orders from the contracting teams due to a need to make corrections either late in design or, worse, during construction.

Feasibility assessment with report (prior to acquisition or lease)

It is generally beneficial for building users to delay signing a lease on a building or tenant space until the space can be reviewed for suitability and potential cost. Building users can request an architecture and MEP feasibility assessment to identify and document items of importance not disclosed in the real estate marketing and lease materials. Engaging the architects and engineers to perform a feasibility assessment can help the building users identify items that could greatly affect the cost of the proposed project.

Typical inspection items include location and size of utility services, evaluation of existing building systems and equipment condition, and documentation of conditions that many not meet current building codes, especially those that would be costly to correct. The building users and design team will review site conditions and establish a preliminary scope of design and construction based on how the space will be used and the overall size of the space required. From that the building user can establish an initial project budget.

Once the feasibility report is completed, the space or building can be evaluated for financial feasibility prior to signing a lease.

By producing the feasibility report before signing the lease, the future building users can negotiate system repairs, upgrades, or simply avoid a financial debacle.

Our experience

A client was interested in a high-profile space that had the potential for high sales volume as well as advancing their brand recognition. Although the client visited the space several times, it was only after reviewing the MEP site survey that it became evident the building's domestic water, natural gas and electrical utilities were not adequate. Meeting the client needs would take excessive spending to update and upgrade the building's base utilities. Since the site survey and report documented the existing conditions, a review of the feasibility report with the MEP design professional allowed the future building user to make an informed decision on the property and avoid budget-busting expenses without committing to the space.

Preconstruction site assessment

Site survey with report

The purpose of a site survey is to verify existing conditions, properly documenting them for consideration during the design process. For the future building user's protection, it is important to thoroughly understand the space before investing time and money in design. If existing space conditions are not clear to the design team, most often because of incomplete or inaccurate information, the final design may not align with existing conditions, which can lead to costly redesign, rework, field changes, and change orders.

A complete site survey by the design team provides documentation of the physical conditions of the building or space to the design, which can reduce additional costs during construction due to unforeseen conditions.

When survey information is inaccurate, incomplete or simply not available, members of the project team are sometimes forced to proceed based on educated assumptions. The team will communicate these assumptions to the building user, who now must decide how or if to move forward. If these assumptions prove to be incorrect or inadequate, it can affect project scope and timeline, and increase risk for both the design team and the building user.

Our experience

Dialectic performs site surveys for our clients because of "as-is" leases and the need to adapt design to existing conditions. Landlords wish to avoid additional costs and usually take no responsibility for the existing conditions of the space.

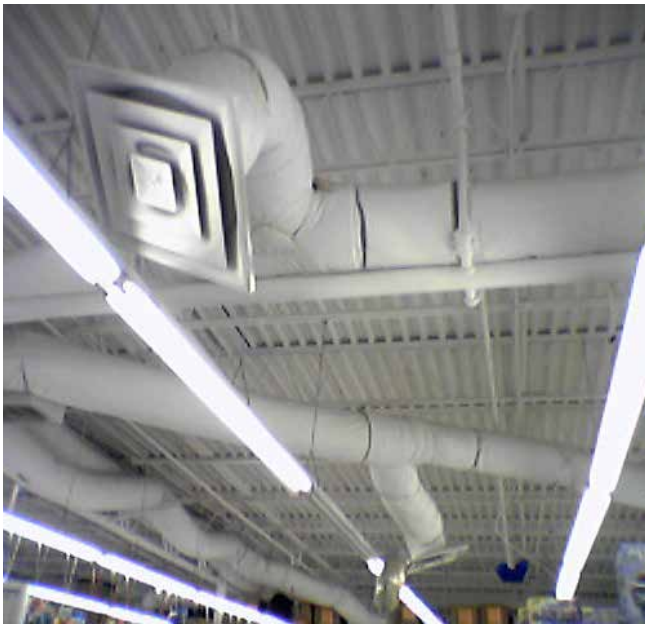
The MEP survey documents the existing conditions that need to be accommodated in the design process and identifies potential issues that may have been hidden or otherwise overlooked during the lease negotiations. Although third-party survey reports provide information of the existing building conditions, they usually do not provide feedback with recommendations prior to beginning the design. This is where a design professional with a background in MEP systems is crucial. He or she will know the specific information required for a successful design, where to look for it, and how to correctly identify it. Without this background, the information provided could be incomplete or missing altogether and could result in additional costs such as a supplemental survey and subsequent design revisions.

A site survey documents information such as:

- Water services size, location and pressure
- Sanitary waste piping locations and sizes
- Storm pipe size, location and routing
- Electrical power services, disconnect location, distribution panels, grounding and sizes
- Data system/phone system entry, capacity and type
- Air system locations for outdoor air, toilet exhaust, smoke evacuation, exhaust fans, main ductwork sizes and locations
- HVAC equipment sizes and locations
- Exterior louver sizes and roof opening issues
- Existing insulation and glass areas (where possible)
- Structural clearances and structural types
- Existing equipment or system obstructions
- Existing drawings
- Project code requirements
- Exterior wall and glazing areas

The site survey is an important part of the design process. It informs design decisions that have an effect throughout the life of the project.

It is best to perform the site survey before proceeding with design. If the site survey is performed after design has begun, items may be discovered that can cause permitting or construction delays.



Poorly installed ductwork

Post-demolition site survey with report

In many cases a site survey is performed while a space is occupied and in operation, with limited access to the existing conditions of the utilities and services. This can adversely affect the quality of the site survey findings as elements may be obstructed by existing fixtures and may be concealed within walls.

A post-demolition survey is an inspection of the space without obstructions such as walls, ceilings, fixtures and millwork. The contractor typically performs this inspection after the building user takes possession of the space. **In most cases the design team is not present.**

A post-demolition survey gives the team the opportunity to update the design to accommodate new information. This is especially important for spaces that have unique design features such as high ceilings and architectural elements that must fit. Based on the project's complexity, it is highly beneficial to have an MEP design professional participate in the post-demolition survey to better inform the design team and to make necessary design revisions.

The post-demolition survey report is similar to the initial site survey but will highlight the conflicts that were not accessible during the initial survey and provide dimensions for fitting specialty items in areas where tight tolerances are necessary. The primary audience of this report is the design team and the contractors.

Our experience

We recently had a client who had identified an older property in a location with what they perceived as attractive demographics for their products, but the building was listed as-is with many deferred maintenance issues. Because the tenant was still occupying the space, our client ordered an initial feasibility survey. This survey was conducted under adverse conditions, with the existing tenant uncooperative, the space still open to the public, and all the fixtures and merchandise obstructing access. The feasibility study provided the information the client needed to negotiate a favorable lease despite the significant number of issues to address to bring the building into compliance with modern codes. The client was willing to bear the risk of renovating this site but still needed to reduce the renovation costs to make the project viable. After conferring with our design team, a possible avenue was identified that could reduce the construction costs by reusing the existing ductwork. A post-demolition survey was ordered to map out the ductwork. With the merchandise and floor fixtures removed, a single day of survey provided the design team all the information they needed to create drawings and provide a significant reduction in the construction budget.

Construction administration phase

To reduce overall design fees and travel expenses, some building users may decide to forego architectural and engineering services during the construction phase of the project, including site visits to observe the work.

Site observation with report

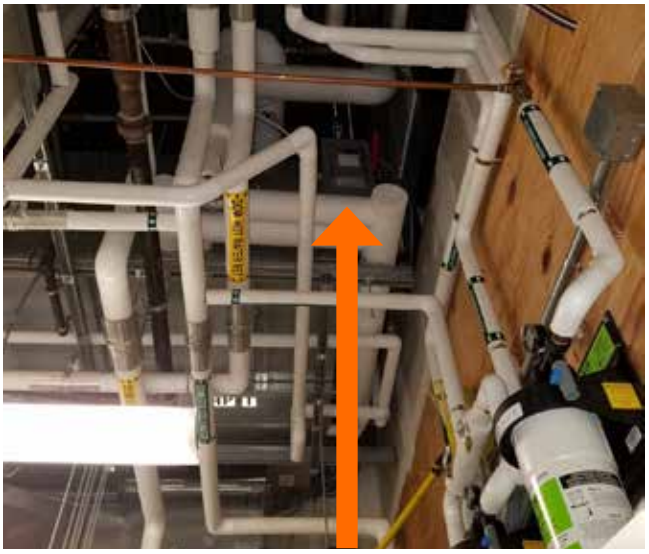
Building users should evaluate their project's tolerance to deviation from the design intent and whether their use of the delivered space would be affected by unanticipated deviations. For a typical project, are the subcontractors building to the contract documents? Are deviations and deficiencies liable to cause unacceptable effects to the use of the space? If the building user feels correct installation of the building systems is critical, the building user or his designated representative and the engineer should establish intervals during construction for observation of construction progress by an MEP design professional.

The benefit of these interim observations is that they ensure the onsite work matches the design and is constructed in an acceptable manner. Construction observations can occur multiple times and are determined based on the complexity of the work. With feedback from observation reports, the building users and/or architect can determine the percentage and quality of work completed, work with the contractor on installation advice, and address any issues prolonging the project or affecting its future operation.

The **CSI Manual of Practice** recommends mechanical and electrical engineers to perform periodic observations so they can become familiar with the progress and quality of the work, to keep the building user informed, and to guard against defects and deficiencies in the work. Also, periodic site observations help to ensure:

- Coordination between design and construction
- Timely communication between all stakeholders
- Conformance with contract documents
- Nonconforming installations can be identified and corrected while readily accessible, reducing their effect on the construction schedule

Many standard agreements for design professionals require the architect or engineer to make site visits at intervals appropriate for the various stages of construction. The design team should determine the critical milestones based on the construction schedule, duration and complexity of the project, and should communicate with the architect and the contractor on construction progress.



Air handling unit with no access for service, which results from of lack of site supervision during construction

At Dialectic, we stress the importance of site visits to observe construction. This can help reduce contractor errors, check for quality of work, and point out deficiencies. Early notifications of nonconforming work can eliminate project delays and cost overruns, and ensure that quality projects are delivered on time. While engineers cannot foresee all issues or identify all defective work, they can resolve many problems that could adversely affect the project. Some code agencies and departments require engineers to make site visits during construction as part of their service, because they know the quality of work and the design intent have much better outcomes as a result.

Below-slab observation with report

Before concrete floors are placed on grade there are various systems that should be reviewed, including electrical and plumbing systems. During this phase of construction, electrical conduit and plumbing can be reviewed for proper material, position, installation and support in accordance with construction codes. This can prevent problems such as improper material uses, joining methods, and liberties taken with design compliance. There is nothing worse than finding that piping was not connected below the slab weeks or months after construction (it happens).

A site observation report will document the progress of construction and observed deficiencies. The field representative from each discipline can meet with the construction team to discuss ongoing issues and provide added clarity to the design team on these issues. These visits ensure construction conforms to the design drawings and specifications for installation, materials and fixtures. This report informs the stakeholders of any noncompliant work and confirms that the contractors have the required information to make corrections.

Our experience

During a site observation, the engineer noticed that the work in progress for an underfloor air distribution system (UFAD) did not comply with the contract documents, including multiple leakage points in the supply-air plenum. If those had not been discovered before the access floor installation was completed, the system would not have operated as designed. Furthermore, it could have taken a significant amount of time to determine the cause of the system failure. One of the critical factors for a UFAD is to ensure that air leakage is kept to a minimum, since leakage can result in system airflow and thermal inefficiency. Air leakage that bypassed the supply plenum would have led to wasted fan energy and uncomfortable space conditions. Because the nonconforming work was observed before the raised floor was installed, the contractor could correct the deficient work without delaying the construction schedule, and the completed system operated as designed.

Interim (rough-in) site visit and observation with report

Informal, interim site visits can address conflicts or design issues that may appear during construction. The engineer provides expertise to assist in resolving the issues. Observations are an all-encompassing review of the construction means and methods employed by the contractors to ensure design compliance.

This helps ensure the system will work as designed or identify issues at a time when it is more cost-effective to resolve them. At this stage, the engineer can review MEP work including piping, ductwork, and conduit rough-in before that work is concealed within walls or above ceilings. Once the walls and ceilings are in place, issues are much more expensive and time-consuming to identify and resolve. After each observation visit, the engineer provides reports on the installation and status of the MEP system to the building user and architect. If the engineer observes deficiencies or errors, he or she can inform the contractor's superintendent while on-site. The engineer and construction team work together to identify deficiencies and errors, and collaborate on the best way to resolve them. The engineer will send a follow-up report to the building user and architect.

Not performing periodic observations may result in performance issues after project completion, when they are costlier to correct. This may also delay the certificate of occupancy, which means even more additional costs.

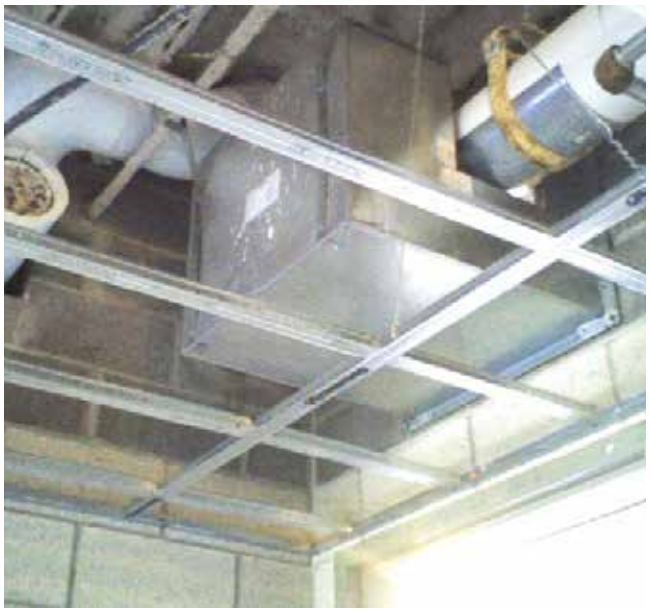
It is critical that deficiencies reported are submitted to and reviewed by the building user or a designated representative, and correction coordinated with the responsible contractor.

Our experience

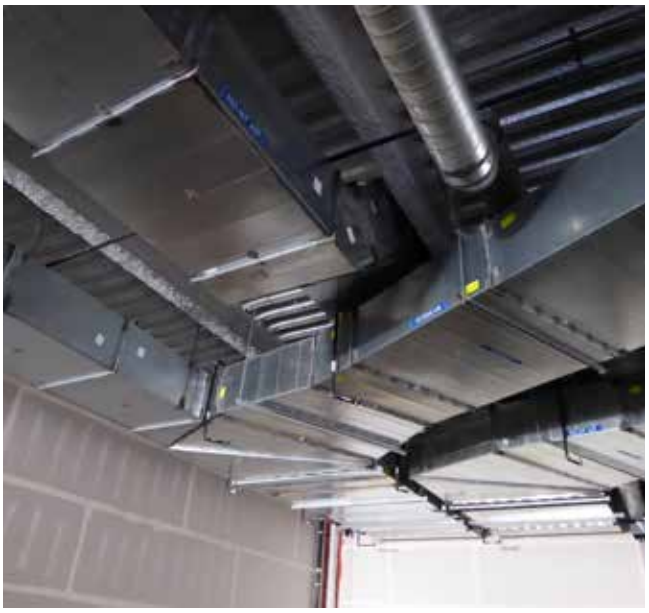
A retail client in a subtropical climate zone had a rooftop unit (RTU) that was specified with dehumidification in the contract documents but not provided in the unit. The deficiency was reported in the site observation report for correction. A follow-up visit to confirm that the corrections were made was not approved by the building user. Corrections required previously were not made until it became obvious that excessive humidity was damaging merchandise. Because of the delayed response, costs associated with repair were excessive. These included closing the store to replace the unit, replacing damaged merchandise, and purchasing a new unit.

On another project, site observations were not included as part of the engineer's scope of work. More than a year after the project was completed, forensic review of the work revealed shoddily supported storm risers had burst during a rainstorm and caused significant crawl space damage. It is highly likely this deficiency would have been found during a site observation and the problems avoided.

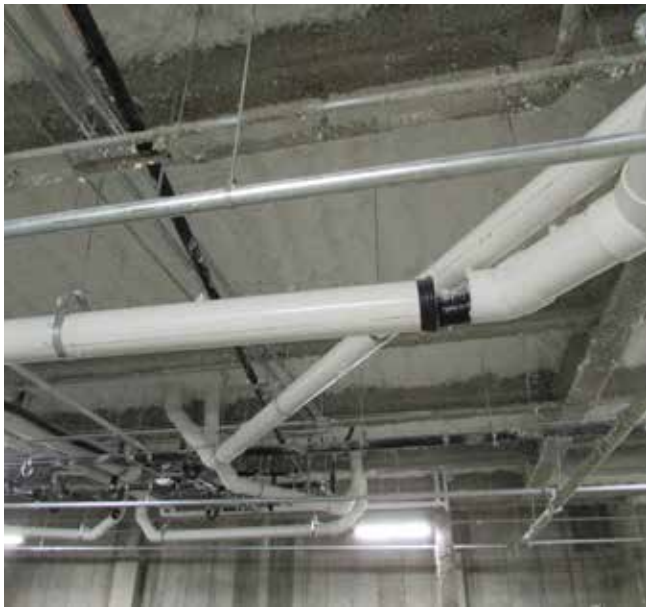
In another example, an HVAC contractor decided to locate rooftop equipment and makeup air equipment in different rooftop locations on a strip-center restaurant. We were asked to investigate why cooking smells were permeating the restaurant, and found rearranged equipment placed such that outdoor air intakes were next to exhaust locations. This would have been discovered on a routine site observation and the costs to correct this error completely avoided.



Roof drain leaders routed through outside air intake duct



Existing ductwork routed through space



Plastic drain pipe used for beverage conduit

Water heater drain routed to floor drain in center rather than one along perimeter

Substantial completion assessment with report

Interim architect and engineer inspections are often used to establish the date of substantial completion. Substantial completion is the stage in the work progress when the work is sufficiently complete to occupy or use the space for its intended purpose. Once the contractor has notified the architect and engineer that the work is substantially complete, the architect and engineer will perform an inspection to determine if the work is truly substantially complete or if additional issues need to be addressed prior to turnover.

At this stage, the engineer's inspection should not be exhaustive, and the list of deficiencies should not be lengthy, provided interim site observations were performed at appropriate intervals. Since much of the MEP work will be concealed at this point, observation will likely be limited to work that is accessible. However, it is imperative that nonconforming MEP work be identified, and that a substantial completion report be issued. If the work remaining is too extensive or if there are items that affect the building user's ability to occupy the building, the project may not be considered substantially complete. This procedure is intended to protect the building user and help ensure that the final building or space meets requirements as defined by the entirety of the contract documents and provided for in the contractor's bid.

Punch list site visit with report

A punch list in today's vernacular is a written numbered list of all found incomplete, deficient and defective work on the project that requires attention. The punch list is usually included in a report with introductory commentary. The site visit when the punch list is created is performed by one or more project engineers, or a project manager toward the very end of the construction. The items on the list can be incomplete work, marred finishes, nonspecified product substitutions, noncompliant material or other improperly installed work. It is a summation that documents for the building user what remains to be completed and allows time for the contractor to correct any reported issues. The contractor is required to address or correct each numbered item prior to the project being truly considered complete. It generally requires a signed statement from the contractor certifying that all the items have been properly addressed and any exception taken.

Final site review with report

For the final observation, the engineer or a trained inspector returns to the site after the punch list items are certified as complete. This observation would take place prior to the end of construction. The feedback from this observation ensures the building user has accurate site information and can release any payment being held for punch list completion.

Ice maker production reduced due to no ventilation above unit. Unit obstructs access to lighting fixture.

Rooftop goose neck added to prevent ingestion by RTU economizer

Our experience

During a site observation visit, it was noted that installation of a grease exhaust duct above the roof did not meet the requirements of the design. Had this not been addressed and corrected, it would have failed within a few months, causing the client's business to close.

Post-construction

Functional performance testing

Functional performance testing (FPT) should be provided as identified in the building user's project requirements or commissioning plan. The FPT ensures critical systems are operating as designed before final project acceptance by the building user's representative. The FPT must be completed by the designated contractor and witnessed by a representative of the design professional (engineer of record) or the commissioning agent. All tests results should be documented at the time of the test and signed by all testing parties and witnesses. All deficiencies noted should be corrected and the affected systems retested if deemed necessary by the design professional and building user's representative. The FPT planning, testing and documentation process should comply with ASHRAE Standard 202.

Although systems may appear to be installed properly upon inspection, the FPT determines if the systems are functioning correctly and delivering a final building/space to the building user that meets the project requirements as originally defined.

Commissioning

Although outside of the scope of this paper, commissioning of building systems is another important field service that can have a very positive effect on a project. Commissioning is a systematic quality assurance process that verifies building systems are designed, installed, and performing as intended. Including commissioning often leads to reduced energy cost and enhanced building system performance. According to a Lawrence Berkeley National Laboratory report, commissioned buildings show whole-building energy savings of 13% for new construction and 16% for existing buildings[1].

Although commissioning used to be a voluntary activity, recent building codes have expanded beyond basic life safety. With most of the model building codes now including building energy efficiency into their scope, commissioning is now required in some jurisdictions.

Building codes that mandate commissioning processes include:

- International Energy Conservation Code (2012 and 2015 Editions)
- ASHRAE Standard 90.1 (starting in 2013 for projects larger than 50,000 square feet)
- California's 2016 Building Energy Efficiency Standards (Title 24, Part 6)

The basic steps necessary for building systems commissioning include:

- Develop and review the building user project requirements
- Develop commissioning plan
- Perform commissioning design review
- Develop verification checklists and functional performance tests
- Perform verification checks
- Perform functional testing
- Develop commissioning report
- Verify training of building user's staff
- Resolve outstanding commissioning issues

The field services portion of the commissioning process includes observation of verification checks, functional performance testing, commissioning report and, if necessary, follow-up site visits to validate correction of deficiencies. Our experience is that commissioning is a valuable service that provides substantial benefit to projects provided the commissioning agent is part of the design team from the start.

System validation

While not exactly commissioning, system validation is a testing of all sequences of operations of all MEP systems. This is a way to shake down the systems under live testing to see if equipment, alarming and devices operate in sequence to match the engineer's intent during all potential scenarios of operation.

This is very important for functioning of all the building's systems, including generator operation, switchgear operation, seasonal change of HVAC systems, fire alarm activation and integration of HVAC and electrical systems.

For example, the last thing you want to have happen under power failure is for your data center or computer facility's cooling equipment to fail to initiate because everyone assumed it was programmed correctly to do so. Without witnessing it function, there is no way to know. Had a system validation been performed, barring some other failure, it should be able to handle the power failure condition without issue.

CONCLUSION

Each project is unique and there is no definite way to quantify the overall savings in cost or time at the onset of a project that the addition MEP on-site services provides. There are too many factors involved. Intuitively, it makes sense though. Experience has shown that while one project may have no construction-related difficulties, another, nearly equivalent project is plagued with issues. It is impossible to assess the different conditions people can bring from project to project, yet they can largely affect costs when trouble or unforeseen issues arise. Through our more than 30 years of experience with multi-industry projects and at all stages of projects, it is our recommendation to always ensure your projects receive the proper scope of site assessments, construction observations and completion services. We have great relationships with our clients, and this is why we stress the importance of these services.

In the end, the more you can know about your project, the better your chances of successful completion.

References

1. Mills, Evan (2009). "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions." Lawrence Berkeley National Laboratory, Berkeley, California, USA

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