

INTRODUCTION

THE PROBLEM:

A recent national survey identified heating, ventilating and air conditioning (HVAC) problems as the number one complaint lodged by survey participants regardless of facility type.

Owners, architects, contractors, equipment suppliers, building occupants and especially mechanical and electrical engineers are all disappointed when their systems work poorly or don't meet the owner's expectations. Too many times the engineer, architect, contractor and building operators come to a meeting and everyone ends up pointing fingers and not coming to resolution on how to make a system work properly. Mechanical and electrical engineers are not only embarrassed and frustrated, but lose clients and business when the systems they design are a problem for anyone.

WORKING TOWARD A SOLUTION:

The Consulting Engineers Council of Minnesota (CEC/M) has formed a group of mechanical and electrical (M/E) engineers to specifically address these problems. The group, called the Mechanical/ Electrical Practices Group (MEPG), represents over 90% of the consulting mechanical and electrical engineering firms in the State of Minnesota. Its members are dedicated to giving owners a cost-effective system, building occupants a comfortable environment, architects and contractors a well coordinated design and in the process making everyone's work more pleasant and successful.

Over 95% of survey respondents believe that mechanical / electrical engineers add value to the project.

EXECUTIVE SUMMARY

Since early 1998, the MEPG has gathered input from owners, architects, general contractors, subcontractors, equipment suppliers and building occupants to examine the design process and review industry standards for mechanical and electrical system design and construction, with the goal of finding and documenting ideas to significantly reduce the mechanical and electrical problems found in buildings. The MEPG met with representatives from each of these entities to discuss mechanical and electrical design issues and problems. Meetings were also held with representatives of state agencies and other design professional associations, as well as with other engineers from around the country.

A summary of our findings indicates that a successful project utilizes the following key components:

In today's market, M/E engineers' project costs are usually 40-50% of a new project.

With these high stakes, the M/Es need to be active team players...¹

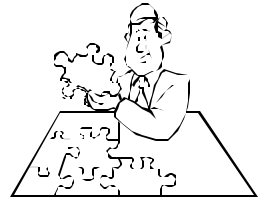


Communication

- Early involvement of the owner and operator with the design engineers
- Open dialog with all parties during design and construction

Coordination

- Identify who is responsible for overall project coordination/leadership
- All parties have to take responsibility for coordination of their work with all others during design and construction



Cooperation

- A spirit of cooperation must exist between owners, designers and contractors to ensure the integrity of the project

Compensation

- Budget for adequate fees to design a project that will meet the needs of the owner
- It is in the owner's interest to understand the fees paid and the scope of services provided by the engineer for those fees
- Along with excellence in service comes fair compensation
- All parties should make a commitment to pay fees in a timely manner



This document is the result of our findings. Recommendations for improving projects on the part of engineers, architects, owners and contractors are included on pages 3-4 and are based on input from survey respondents and from members of the MEPG.

A more detailed summary of each area of discussion follows, beginning on page 6. It is the hope of the group that this document can be used as a starting point for discussions with others involved in design and construction to improve relations and ultimately provide a better project and process for all involved.

RECOMMENDATIONS

Utilizing the input of survey respondents, the MEPG has developed recommendations that, when used by all parties, will result in projects that run smoother, will lessen conflicts and confusion and, ultimately, will provide a building that most fully satisfies the owner's needs and expectations.

Recommendations for the engineer:

- Meet directly with the owner at pre-design to explain the M/E role and scope of work – what are we hired to do?
- Maintain an open dialog with contractors.
- Educate engineering staffs on:
 1. Proactive communication (written and verbal)
 2. Project management (scope, schedule and budget)
 3. Construction cost estimating
 4. How to respond to unacceptable constraints
- Meet with the contractor at the start of a project to review project requirements.
- Offer training opportunities to the building operator(s).
- Know when to say no to unreasonable schedules and budgets.
- Develop scope of service guidelines for use by owners, architects and engineering staff.
- Provide a design that meets the requirements of budget, operability and efficiency as established by the client.

The owner/user must clearly define the requirements and expectations of A/E services at the onset of A/E negotiations so that all parties are on the same page and proceeding in the same direction. ²

Recommendations for the prime consultant:

(NOTE: "Prime consultant" refers to the holder of the contract with the owner. "Subconsultant" refers to those contracting with the prime consultant. Generally, the architect serves as the prime consultant and the engineer serves as the subconsultant.)

- Meet with subconsultants to discuss scope, schedule and fees. Then hold a follow-up meeting with the owner and subconsultants to clarify their roles.
- Facilitate communication between the owner and subconsultants by involving the subconsultants and end user in owner's meetings.
- Foster a direct working relationship between subconsultants and the contractor to better resolve issues and problems.
- Facilitate meetings between the owner and subconsultants on schematic design and design development phases of a project so the owner understands what he/she is getting.
- Include and compensate subconsultants for additional services during the construction phase.
- Understand the informational needs of consultants and schedule timely delivery so the project can be properly coordinated and delivered on time.
- Review budget and schedule constraints with subconsultants prior to making a commitment to the client.
- Pay subconsultants in a timely manner.

Everyone experiences the environment produced by an HVAC system. There is no other single element of construction, except possibly lighting, that is experienced every hour of the day and has as much personal effect as the HVAC system.³

Recommendations for the contractor:

- Communicate directly with the engineer to resolve issues and problems.
- Look/plan ahead for any foreseeable problems.
- Freely communicate ideas and solutions to field problems.
- Meet with the engineer at the start of a project to review project requirements.
- Resolve issues and ask all questions before the last addendum during bidding.

Recommendations for the owner:

- Require a sit-down meeting at the beginning of the project with the prime and subconsultants outlining specific project scope and fees. At a minimum, meet with the prime and subconsultants at the completion of scheme, design development and construction document phases to understand the design.
- Have a thorough understanding of the design fees and the scope of services to be performed for those fees by each member of the design team.
- Freely communicate with the engineer throughout the project.
- Require a design intent document, written in understandable terms, that identifies project specifics up front.
- Communicate critical and/or unusual project requirements to the design team.
- Have a representative with in-house expertise involved with the design process and the project.
- Involve the final system operator in the design process as early as possible.
- Consider contracting directly with each major consultant to improve communication and better control the design process.
- Budget for and contract with the design engineer to provide commissioning and extended construction observation.

SURVEY SUMMARY

The MEPG conducted a survey of mechanical/electrical engineer client groups, intending to provide insight into what makes a successful and enjoyable project. Specific questions addressed respondents' greatest areas of frustration with M/Es, positive experiences respondents have had with the design process, ways in which the M/E brought value to the project and ways in which the M/E can improve their services. A total of 54 responses were received from engineers, architects, contractors, owners and others involved in the design and construction process.

Most often, responses to all questions deal with one of the four Key Components of a Successful Project as noted in the Executive Summary on page 2: communication, coordination, cooperation and compensation. M/Es were both complemented and criticized for their skills in these four areas, not only in their dealings with the owner, but with all members of the design/construction team. The majority of other responses, including owner expectations, change orders, inspections, fees and other issues were all related to communication and cooperation.

Virtually every engineering element of our facilities is designed to be better than sufficient... There is one glaring exception – the HVAC system. The system is normally designed to be insufficient for a certain number of hours or days per year. ⁴

Relying on respondents' suggestions, the MEPG examined possible ways to improve projects by establishing some general guidelines for engineers, owners, contractors and the prime consultant. In keeping with the two most common responses of communication and cooperation, the suggestions found within this document reflect these themes. In particular, the MEPG suggests involvement of the engineer as early as possible in the project, with their continued involvement through project commissioning. The group also suggests direct communication between the owner and engineer early in the project as a means of establishing scope, expectations and engineering options for meeting the owner's needs.

This document is divided into four main areas of discussion as they related to the survey questions:

- Creating a successful project
- Frustration sources
- Positive experiences
- Ways M/Es can improve their services

Creating a Successful Project



...The only reasonable answer is to bring M/E engineers on board as equal partners at the very beginning of a project.⁵

The survey indicated that an overwhelming requirement for having a successful project is a happy client whose needs have been met by the completed project. To meet this requirement, survey responses suggest the following main points:

- The most important, time-tested client need noted was completion of the project on schedule and within budget. To achieve this goal, engineers need to be proactive early in the project design to express their need for information and an appropriate portion of the budgeted funds. This proactive approach will help prevent engineering services from becoming the schedule or budget busters. This item accounted for 17 direct responses and several indirect responses.
- Ten respondents defined a successful project as one designed the way the client understood it would be designed, implying that communication between the client and the engineer is of the utmost importance. Communication could be improved with more face-to-face client meetings throughout the project to help clarify the client's understanding of the design and the designer's understanding of the client's needs.
- Nine respondents noted quality of design as another important factor in project success. Design quality issues ranged from minimum field problems and exceeding design standards to good coordination.
- A series of related but less focused suggestions for a successful project related to the social issues of the project team. The 10 related responses indicated positive results from a long-term partnership with designers, contractors, suppliers and the owner. Others felt that treating all team members fairly was important to project success. One respondent stated that a successful project was one in which no lawyers were involved. These comments would indicate that engineers could be more successful if they interact with other team members ethically and supportively.

If we tell our HVAC engineers to design a system that virtually guarantees dissatisfaction and they do what we ask, why do we get mad at them?⁶

Frustration Sources

The survey indicated that the most common sources of frustration in completing a project are as follows:

- The main frustration source is a lack of coordination from project start-up to project completion. Specific problems noted include lack of information, inadequate programming, equipment that does not fit and poorly coordinated documents.
- The second most common frustration source is a lack of communication between owners, designers and mechanical and electrical engineers. Specific problems noted include lack of response to requested information, no desire or inability to communicate and lack of understanding of building systems.
- Changes in building design and increase or decrease in project cost were also frequently mentioned.



Specific frustration sources mentioned by survey respondents include:

- Miscommunication between M&E, architects, designers and owner representatives regarding systems, which ultimately can lead to unfulfilled expectations.
- Not enough time or fee to design a good system with enough information on plans for good installation.
- Lack of coordination between all disciplines and poor communication between all disciplines, owner and contractor.
- M/E engineers do not listen well to new requests and instead do their standard.

Positive Experiences

Most of the responses noting positive experiences can be associated with four themes relating to engineers: team players, expertise, project delivery and accessible and responsive. Architects mentioned team player and expertise-related experiences most often, with five responses each, followed closely by accessible and responsive with four responses. Project delivery was mentioned only once. Eight contractors responding felt engineers were team players, while each of the other three themes received two responses each. Owners most often cited the engineer's expertise (three responses), with one response for each of the remaining three themes. Overall, "team player" received 14 responses, followed by "expertise" with 10, accessible and responsive with seven and project delivery with four.



The best projects have had thorough and enthusiastic M/E input from programming through design and occupancy, including visible support from engineers and the personal commitment of principals.

The following comments are excerpts from the survey that highlight these themes:

M/Es are team players

- A group of design professionals and contractors were brought together to accomplish the project on a very tight budget and time schedule. There were no prima donnas; all entities worked together.
- When faced with problems, the project engineer and I will often coordinate by bringing the field experience from my firm and the design experience from his. We often find the best solution for the owner.
- (M/Es provide) positive interaction/response to system field problems. Positive design leadership. Good team players.
- (M/Es were involved) beginning with the development of the project concept with a team that included the owner, architect, general contractor, subcontractor and all engineering disciplines.
- Everyone worked together as a team (owner, architect, engineer, contractor) to make the project complete and workable and made the owner happy.

Expertise

- (M/Es provide) a strong knowledge base when design or reasoning is questioned during construction. It is comforting when the design is defensible during the construction phase.
- Engineer recommendations (can) result in a better system for less money.
- Minnesota has good engineers. They bring a high level of expertise to design.
- (The M/E) worked early to involve trade experts and establish a team to deliver best first cost (and provided) an exceptional cost solution.
- (The M/E engineer) stepped up to fix mistakes; reciprocating with new work or leads for the architect firm. Acting as an advocate of the client. Suggesting cost saving alternatives.

A successful project is one where HVAC design engineers are willing to try different approaches to solving HVAC layout problems.

Project Delivery

- Project delivered on time.
- (The M/E provided) follow-up on building balancing and commissioning, staying with the problems.
- (Successful projects are those) with well-defined goals and owner expectations, then execution and follow-up, usually with heavy participation of principals and top-end engineers.
- (Successful projects are those where) the building is completed, started and works as designed.

Accessible and Responsive

- Best projects have thorough and enthusiastic M/E input from programming through design and occupancy, i.e. very visible support from engineers and personal commitment of principals.
- The design engineers are often on-site to see and listen to problems and help resolve them as soon as possible.
- Their project managers take charge, solving problems and taking responsibility.
- (M/E provided) good communication throughout project. M/E firm (was able) to respond quickly and often to required changes.
- Thorough up-front communication yielded "smooth" job (and) frequent mid-construction visits relieve confusion at punchlist time.

Ways M/Es Can Improve Their Services

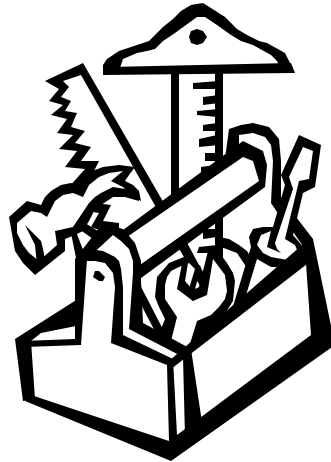
Sixty-three separate ideas relating to improving M/E services were received from 45 respondents. Significantly, nearly half of the responses dealt with people-related issues rather than technical issues.

People

Communication appeared as the most frequently mentioned people skill that engineers need to improve. Responses centered around improving communication with the owner and other members of the design team, especially when explaining the rationale for design decisions and the impact they will have on the project. Engineers were also encouraged to ask

questions and not simply wait for information to be shared, as well as to listen to owners describe the system history in existing buildings.

Another commonly mentioned area for improvement was teamwork. Suggestions included admitting mistakes, providing better and more timely coordination, focus on solving the problem and having the engineer more involved earlier in the design process.



...Funding available for construction is often less than required to provide an HVAC system that meets the owner's expectations. 7

Specific people-related comments include:

- Review projects more with architect/owner to establish expectations
- Develop clear understanding of owner's needs and deliver clear presentation of how design meets needs
- Help owners/architects appreciate good engineering
- Be better partners in the design and construction process
- Be flexible
- Involve consistent and capable personnel and project leaders
- Have a service attitude

Services

Twenty-four comments related to services provided by M/E engineers. Of these, all but one involved improving or increasing services without mention of fees. The most common comments dealt with the need to improve coordination. Other suggestions involved being more innovative, tailoring specifications to the project and being more sensitive to the architectural design.

Testing and commissioning work should be highlighted and recognized as a final summary of the performance of a new or retrofit HVAC system.⁸

Specific services-related comments include:

- Don't crank out design at the last minute
- Complete the design before bidding/pricing
- Provide post construction walk-through with the owner every three months for two years
- Consider future problems-access-repairs
- Provide better construction phase support

Other

Several additional comments dealt with the engineer's relationship with the contractor, including the need for engineers to stay current with construction costs, involving contractors early in the project and being more cooperative. Fees were also mentioned, relating to the difficulty of explaining engineering fee requirements to the owner and making sure accepted fees meet scope of services requirements. Finally, one respondent mentioned the engineer contracting directly with the owner.

¹ Woody Franklin, *IEA Environmental Consultant*, "Why Hire Mechanical & Electrical Engineers Separately?," spring 1998

² Federal Agencies/ACEC HVAC Task Force, *Probable Causes of HVAC Problems*, May 1996

³ *Probable Causes of HVAC Problems*

⁴ William E. Howard, *Health Facilities Management*, "Dissatisfaction Guaranteed," September 1997

⁵ "Why Hire Mechanical & Electrical Engineers Separately?"

⁶ "Dissatisfaction Guaranteed"

⁷ *Probable Causes of HVAC Problems*

⁸ *Probable Causes of HVAC Problems*

** All other unattributed statements are excerpted from statements of survey respondents.