428.pdf

A SunCam online continuing education course

Creating Effective Teamwork In Project Management

by

Gerald May, PE

Course Description

Throughout our careers we experience conflicts and friendships that effect our professional performance. While technical competence is necessary, often the difference between success and failure on each of our projects may depend on our ability to work in a team environment and the management of these teams. The "team" you are on may not be as obvious as it first appears. Certainly, if you are working for a company, that is your team, as well as the project team in the company you are part of. If you are on a team to design and build a facility or product you are part of the team that performs the planning, design, procurement, fabrication, construction, quality assurance, start-up and the operations – even if you are not part of the company that performs some of these actions, and you have never met a single individual that is performing these other functions.

Another way to look at this is as if you are giving a speech. Communication experts preach that you always pay attention to your audience, and speak or write for them, not for yourself. Engineers communicate with our drawings and supporting papers that are used to build and operate a device(s). If the only communication is by drawings and documents, then they must be as complete and accurate as possible. (The author has never seen a perfect document or drawing. There is always something that seems unclear to someone trying to follow the information.) This course provides some guidance on how to make this teaming work, based upon some real incidents that illustrate the successes and problems that can develop depending upon the quality of management, the adherence to basic principles and respect for others. While written around design and construct projects, it applies to any project team.

It is intended by reading these issues, the student may help a project team become a truly functioning team that recognizes and avoids common pitfalls.

Be prepared that some people on your team will not necessarily have a similar background to yours. You cannot assume business language, customs and interpretations will be identical. No matter who is on the team, treat them with respect and courtesy.
(U.S. Army photo from Afghanistan)

1.0 TEAMING PRINCIPLES

1.1 Personal Attitudes

There are some basic principles that should form our attitudes when we work with other team members:

1. **Everyone on the team knows something that could be helpful.**
2. **Nobody knows everything about any particular topic.** Even the most learned expert still has questions about some details. "Experts" can also fall into the trap of being used to doing something well a particular way, and they become "blind" to alternative ideas and methods.
3. **Everyone should want to contribute to the success of the team**. This is a rephrase of one of W. Edwards Deming's concepts that "No one gets up in the morning and says, I hope I can do a really bad job today." (NOTE 1)
4. **Keep an open mind to what others have to say.** This goes for "The Rookie" and the "Most Seasoned Worker." Human nature is such that if someone is defensive or comes up with non-technical reasons such as, "I was taught this is the only way"; or "I know what I am doing"; or "I've been doing it this way for 25 years and it has always worked", they are not having an open mind. If you have technical or economic reasons for your position state them. If not, listen openly and see if others have better options.
5. **A good team member provides ideas and leadership to the other team members.** A team member who just does what they are told without ever speaking up and offering suggestions, is not providing their full effort to the project team. A good team member must think and participate.

1.2 MANAGEMENT ATTITUDES

Individuals may have the best of intentions of working well in a team environment. However, this can only flourish if Management encourages that environment. Management includes all those who have active roles in assigning work and making decisions. On some major projects there are multiple layers of managers who need to model the teaming attitudes, and to foster it in those who need help in understanding how it should work.

Managers should

- listen well,
- make informed decisions

- explain their reasons for various decisions
- model what they expect of their team members
- hold in check those that are not good team members
- promote those who exhibit good teaming skills.

However, management at some companies includes a culture that may not reward good teamwork. Look at what is measured and how management reacts to missed targets. Teamwork requires trust, good communication, and planning that reflects reality. When projects are falling off schedule or budget, a good team jointly develops positive corrective actions. If there is finger pointing instead, or knee jerk reactions without planning, then management is not supportive of a teaming environment.

To be fair, project management is working with multiple groups and organizations that are all have their own agendas for profitability, quality and schedule. Dr. Jeffrey Pinto, Ph.D. expresses that if a Project Manager is “mildly irritating” to all of the groups, he/she is probably doing their job properly. (Ref. Suncam course 030, “How your projects will go wrong (and what to do about it”).

Project Management is not directly discussed in this course but it is recognized that the job is not only to assure the project is planned and executed properly, but to do so with other agenda items that may be counter productive, such as:

- Short term (or long term) profit requirements
- Cash flow management
- Contracts that reward based on arbitrary dates or other requirements that have no real effect on the production of the final product. (See example 2 below)
- Demands from upper management for immediate results
- Legal requirements that restrict sharing of information
- Company rules that limit sharing of sensitive information
- Trying to “look good” for the next promotion
- Client demands for productivity and results
- Political pressure from government agencies and politicians
- A corporate culture that rewards authoritarian management rather than effective teaming

And of course, managers are people that have the same issues of ego, self-doubt, wanting to appear knowledgeable and competent, and wanting to be appreciated by their management, that almost all of us have. Unfortunately, some managers seem to just be interested in wielding power and whatever success their projects have is based more upon fear and intimidation, rather than teamwork. These types of managers may be successful at times, but not nearly as successful as they would be if they could effectively foster teamwork.

When facing decisions, Bob Cate often asked us, “What is the right thing to do? The profits and other issues will take care of themselves if we do the right thing.” It was usually a correct statement, if his managers were thinking the same way.

Managers who promote positive teaming attitudes can be effective “Team Leaders”. Those that do not are “Team Destroyers” and help create the negative results that are almost certain to occur.

Management Examples

1: Public Backstabbing

In a design project a technical manager determined that special seismic restraints were required and assigned Joe to design them. Joe submitted the drawings to the project and heard nothing about it for weeks. He was then summoned without warning to a project meeting with the owner and other outside vendors. The Project Manager angrily questioned why the seismic restraints were submitted. While he certainly knew why they were there, he put on a show for the owner at the expense of his own team. It destroyed teamwork as most of the people on the project feared his anger. Certainly, a Team Destroyer.

2: Deliver Material On Schedule Date, Whether It Is Needed Or Not

A large order of pipe supports was scheduled to be designed, fabricated and shipped several months before the field would be ready to install any of the supports. Engineering tried to delay the design date since there were a number of design details that were not fully defined. “The schedule was viewed as mandatory by management”, without any explanation as to why. The pipe supports were designed, fabricated and delivered per the schedule, and the field had no proper place to store them.

The hundreds of pallets were laid down in an open field. Over the months, weeds grew so high that they had to spray weed killer to find all the pallets. The weed killer had the unintended consequence of removing all the marking paint, and they had to pay the factory to have a technician spend a month in the field re-identifying all the equipment. This cost was in addition to the cost of additional supports that had to be purchased to replace those that were mis-designed because of incorrect assumptions.

Management's decision to stick to an arbitrary schedule for no apparent reason, cost them money in the end. It also created an attitude of the individuals on the project that their opinion didn't matter. People continued on doing their job as they were told to do it, even when they knew it was wrong. It was not worth being slapped down when they could just go with the flow. If it didn't work out, they could say, "I was just doing what the Project Manager told me to do."

2.0 TEAMING BEST PRACTICES

There are several areas that must be managed properly to develop a good team on a project. This course assumes that management wants a good teamwork environment. If management fosters the attitudes described above, there are many concrete actions that must be performed by the team. The most important aspects in this author's opinion are described in the sections as follows:

- 3.0 Communication of Product Expectations and Deliverables
- 4.0 Document Creation, including language, document transmittals and Requests for Information
- 5.0 Conducting Meetings Properly
- 6.0 Team Safety
- 7.0 Behaviors, including egos, and how to ask the right question
- 8.0 Effect of contracting methods on team performance
- 9.0 Summary with a description of a "Near Perfect Project"

While it may be perceived that most of these areas are management's responsibility, it is actually every team member's responsibility. Management sets the tone and insists on proper teaming principles, but everyone must do their part. All groups in the overall project team (owner, engineer, fabricators, suppliers, contractors and other stakeholders) must communicate effectively with each other. People need to show respect for one another.

3.0 COMMUNICATION OF PROJECT EXPECTATIONS AND DELIVERABLES

It seems obvious that management must convey the end product and the expectations on quality, scope, schedule and cost to those performing the work. However, this is often not done, or is done in a piecemeal fashion, as if only certain people have a "need to know" certain things.

- What kind of drawings will be produced? What level of detail should they show? Drawing sizes? Are the drawings for fabricators to actually build from, or to show general information and the fabricator creates the detail drawings?
- Will there be engineering representatives on site to answer questions, or will engineering be completed and construction will be done sometime later when the design engineers will probably not be involved?
- Is this a demonstration project that is expected to only run a couple of years, or a plant with a design life of 50 years?
- How is the plant to be operated? With a large staff, or with a minimal staff that requires almost all functions to be automated?
- Will the client or others be present during the design process to assure adherence to their specification continuously, or will there be one or two design reviews at certain points?
- What is the process for resolving technical conflicts and other issues that invariably develop during a design project?
- And hundreds of other detail questions.

Some additional general topics that should be defined for all team members include:

3.1 CONSTRUCTABILTY

Constructability is a concept that was developed for large plants because of construction cost overruns. Often constructability is viewed at a high level of trying to sequence the materials, work, cranes, scaffolds, tools, and crafts to assure that a large plant can be built efficiently. Approached properly, constructability pushes upstream to schedule certain engineering tasks before engineering may be ready. For example, long lead equipment such as large pumps and pressure vessels may need to be preliminarily designed and ordered before all the details are known or concrete foundations may be designed and poured while detail design is still in progress. This creates more interfaces between engineering, equipment suppliers and construction that must be managed much more carefully than just "buy this model pump".

There is also a detailed aspect of constructability that is often important in retrofit work. The design engineers should meet with the craft supervisors to assure something can be demolished and re-built and see if the crafts have some ideas to improve the design.

"Wait a minute! You want a degreed engineer to revise a design based upon what a welder thinks?"

"YES! If the welder knows how they can maneuver a welding rod in a tight spot and they can see ways to fabricate such that they can make the weld easier without loss of integrity, then they need to be listened to. "

Welders, pipe fitters, scaffolders, mill wrights and other crafts are part of the team and their knowledge and opinions should be dealt with respect. If you have a design that may be difficult to build, talk to a Construction Manager or applicable crafts. It is amazing the amount of know-how and creativity they often have.

3.2 OPERABILITY, MAINTAINABILITY & INSPECTABILITY

A similar teaming approach is necessary if there is an attempt to optimize "operability", to assure the plant can be run safely and reliably. Following are some of the basics:

- platforms to all areas that need access,
- valve handles, switches, view ports, and other devices are at proper heights and accessible,
- operating data is saved and accessible for analysis to the appropriate people

- safe access during operation
- computer operating screens that help the operator understand current conditions and trends
- methods to recover from an upset condition
- methods to recover from a power outage.

Owners may require maintainability in the design. This requirement may take many forms, but the most common is to look at the durability of major equipment and determine how long the equipment can be operated before a major maintenance cycle. This may be in years and there are economic studies whether it is worth the extra initial cost to stretch the maintenance from its normal maintenance to a longer interval, i.e. 2 to 4 or 5 years between shutdowns.

Maintainability may also look at redundant systems to allow shutdowns of partial systems while continuing to operate. The most common issue is choosing to install 2 – 100% pumps, or 3 – 50% pumps instead of 1 – 100% pump. However, this concept could be applied to other types of equipment, such as valve stations, metering stations, pollution control equipment and other systems.

There may also be many client requirements and preferences learned from good and bad experiences. The design engineer must listen, ask questions and thoroughly understand the problems they need to avoid. This is a potential minefield of misunderstanding, faulty memory, preferences for one brand of equipment and other myopic viewpoints.

There may also be "inspectability" as a consideration. This may be non-destructive examination of welds, or on-line monitoring of critical temperatures, pressures and flow rates. If Inspectability is a client requirement there may be a necessity to include inspection specialists in the team to review locations and methods of inspection of various components.

<u>Operator Interface Examples:</u>

1: Unusual Request For Particular Vendors

An owner's operator swore the engineer should not allow a certain brand of control valve, but this valve is considered by most as the highest quality available in this service. Turned out the opinion was because that valve manufacturer had a bad factory representative

15 years before and had mislead that client. This is a reasonable viewpoint, except the rep had been replaced many years before. Always ask "why" when specific requests are made, particularly when they restrict the basis for a "good decision". Is the request based upon meaningful data that is consistent with the project goals?

2: Designing Maintainability Into a Plant

The owner of a petrochemical plant included in the design requirements to study the potential cost and schedule benefits that could be realized by buying material and including by-passes that would allow up to six years between major maintenance outages, instead of the normal 2 year interval for this type of plant.

This was a difficult challenge for the engineers who were used to designing for construction and operation, but not including the reliability of the equipment on a detailed level. With training and a lot of meetings between the Owner's operations team and design engineers, many of the issues were worked out.

However, Procurement was not on board and wanted to continue to award equipment contracts based upon lowest evaluated installed cost. Company rules did not allow engineering to even see the quoted prices. Thus, engineering's evaluation that Pump A was significantly better than Pump C for long term maintenance was not even considered by Procurement as relevant. The problems were partially resolved after the first few contracts, but the effectiveness of the program was compromised, and the Owner was not pleased.

Remember that all the Project groups must be involved on decisions they must act upon. Procurement thought they were doing their standard due diligence and was not brought in early enough on the project requirements.

4.0 DOCUMENT CREATION

4.1 LANGUAGE

Most professionals perform well in their own areas of expertise. They understand their discipline and given clear requirements, usually perform their jobs well. Mistakes and other problems are often traced to communication issues between groups and organizations.

Each organization and discipline develops its own lingo, acronyms and methods of performing work. It is unreasonable to expect each group to understand each other group's complete language without some discussion and clarification. Documents must be clear and concise with the minimum of non-standard lingo. Acronyms should never be used without full definitions. Sometimes different groups use the exact same acronyms for totally different words.

Language Examples

1. **Abbreviation, and Acronym Definitions**
   In most plant design work, there is a Process and Instrumentation Diagram (P&ID) set of drawings that schematically lays out the equipment, pipe and instrumentation. Usually the first sheet is a complete list of every abbreviation and acronym that is used in the set. Other disciplines may create a similar drawing, or they may reference an industry standards from American Institute of Steel Construction (AISC), American Society of Mechanical Engineers (ASME), Process Industry Piping (PIP), or other well recognized organizations to be clear on their language.

2. **Acronym Confusion**

   In the 1990's the author was just learning about Reliability as a discipline. At a Reliability seminar all the speakers kept referring to RAGAGEP, which to his knowledge might have been a new coined word or an acronym. Luckily, the 5th speaker finally cleared up the confusion – acronym RAGAGEP Recognized And Generally Acceptable Good Engineering Practice. It can be stated that one RAGAGEP is to always define an acronym.

3. Same words – Same Company – Different Definitions

An illustration of communication with imprecise terms occurred when an engineering & construction company was studying how to improve delivery of materials to the construction site at the correct times. The company was using three schedules, one for engineering, one for procurement, and one for construction. Each had a column headed “Due Date” – but of course the definition for each was different. Engineering’s “Due Date” meant the specification was issued. Procurement’s “Due Date” was ship date. Construction’s “Due Date” was the date the equipment was released for installation. The situation was actually worse because when people in engineering or procurement were asked what construction’s “due date meant; most didn’t answer correctly. Communication was improved dramatically with one project schedule with clearly defined dates. Similar issues can be found throughout the engineering, fabrication and construction disciplines.

4.2 DOCUMENTS AND DRAWINGS

There is an old joke that has a great deal of truth. The craft supervisor keeps calling the engineer asking for clarification about how to build a component. The engineer responds, “Just build it like the drawing shows!” and the craft supervisor retorts, “We would, if the drawing showed something that could be built!”

Maybe it is a simple error of an asterisk is missing and 4’ 3” now looks like 43”. Or a material designation is out of date, or the weld symbol is ambiguous, or there is some other error in the drawing. Maybe the instructions for fabrication are not sequenced the way the crafts typically do their work, or there is equipment in the way of erection that the design engineer doesn’t know about. Drawings often do not exactly match the reality in the field and the team needs to be prepared to resolve these differences.

It is a difficult choice to decide how much needs to be formally transmitted to a fabricator or contractor. At a minimum the basic design with dimensions, bill of material, materials of construction and applicable acceptance standards need to be conveyed. However, there are often specific instructions that get longer with each project. “I never told the Contractor he couldn’t do “X” on the last job and that was a mistake. I will always put that in the notes on future jobs.” Or a note is appropriate for 95% of the work, but there are exceptions. This can lead to perceived contradictions and confusion.

Or perhaps the notes get so long that no one reads them carefully until something goes wrong, and lawyers get involved. Or some notes are more important than others, so they get a larger font, bolded and all caps. Maybe these are read, but the other notes are not studied. (On a personal level, consider how many people read the pages of safety notes and instructions before putting batteries in a child's new toy. It is the same principle with engineering documents: we can say too much)

Another approach is to minimize the notes and instructions and carefully review the Contractor's procedures. Sometimes the procedures are minimal or non-existent, so this often doesn't help much.

No method has ever been found that is foolproof, but the most likely method to result in good results is to develop a team arrangement between the engineer, contractor and other interested parties. Provide written instructions and go over them in detail with the contractor. If the contractor wants to make changes, listen carefully and approve those that can be. Those that can't be approved need to be explained as to why, and probably a Quality Assurance representative needs to assure the Contractor's disapproved proposed method is not used.

If it turns out the Engineer will not be available when the construction is actually performed, then the next best option is to provide detailed instructions with explanations if some procedures or other details are critical. It is suggested that where there might be confusion, provide the end goal instead of a procedure. For example, if there is a tight tolerance between two components, state the tolerance and perhaps a reason for the tolerance. Let the fabricator determine the best method to get that result. These must then be implemented by the Owner or the Owner's representative. Invariably, this will lead to errors in interpretation and it is strongly recommended that the original engineer be made available on a consulting basis through the construction process.

4.3 TRANSMITTAL OF DRAWINGS & DOCUMENTS

Drawings and documents should not be issued without clarification meetings which should include:

1. Explanation of the intent of the information
2. Overview of what are considered the most important points

3. Sufficient time for questions and answers.
4. Open discussion of how the recipient may see improvements from their viewpoint.

Perhaps two or more meetings are needed to clear up details and to allow recipients time to study the information carefully. These do not all have to be formal meetings when a quick conversation or email discussion suffices.

4.4 REQUESTS FOR INFORMATION & CLARIFICATIONS

As noted earlier, the author has never seen a drawing that someone doesn't have a question. This often happens when a contractor or fabricator is determining how to build the device and they just aren't sure what is needed or intended. If you receive an email, phone call or other request, welcome it and treat it with a high priority.

1. The questioner is trying to make this device the way it is intended, and the project team should be very pleased that the companies brought on to do these functions care and are trying to do their job properly.
2. There may literally be a crew that is waiting for an answer and the costs are mounting.
3. If the answer does not come fast enough, the crews may be reassigned to a different job and this task may be put off for days or weeks until they get back to it.
4. If this is in a shop environment and the answer does not come fast enough, the task may lose its place in the shop schedule and the delivery date is missed.
5. If the answer does not come soon enough, they may guess at the answer which may force re-work if their assumed answer is incorrect.

Also, look at this from a teaming approach. It is quite possible that the design team has 20 or more people available to work out issues. Often in the field there is one person trying to answer all the questions from craft personnel and keep the work flowing. It can be a very lonely situation if the design team is not responding promptly to requests for information and clarifications.

It is impossible to overstress the importance of communication at all interfaces of groups and organizations, as this is where understanding is likely to breakdown, and a project is not completed successfully.

An analogy that is sometimes helpful to the engineering community. When structures, pipe or electrical components physically fail, it is very rarely in the middle of I-beams, pipes or wires. Failures almost always occur at the connecting points, such as beam to beam or beam to column bolts and welds; pipe welds, flanges and branches; or at wiring junction boxes. Likewise, the projects usually do not fail because of a particular discipline, but because the interface between groups is not handled properly. Structural needs design loads from piping, electrical needs equipment load requirements and detailed interface information, instrumentation and control needs requirements from process and a multitude of other information transmittals. Equipment vendors need clear specifications, and construction needs to have drawings and instructions that draw all of this together properly. Focus on these interfaces and prioritize responses to these groups when requests are made.

5.0 CONDUCTING MEETINGS PROPERLY

Whether in person or virtually, meetings can be a useful tool or a waste of time. Meetings can be used to solve problems but can sometimes disintegrate into a destroyer of trust and goodwill. Textbooks have been written and seminars provided on how to conduct effective meetings. The purpose of this discussion is to provide a few basics and help recognize the importance of meetings in making the team effective. Meetings can be any size group of people who discuss a particular issue. Very effective meetings can be between 2 or 3 people in 5 minutes. Think about how these conversations are effective. Usually they are between people who are focused on one issue and need to resolve it to move on with their work. Probably the people respect each other and try to understand the other person's views.

You have probably had other discussions in which one person demands the others take his/her view and will not listen to reason from others. In the worst cases, the dictator does not even explain his/her rationale. This shows disrespect.
Between these two scenarios there is no doubt which type of meeting most people would choose. When meetings have more people, the potential pitfalls grow with each additional person. Some observations:

1. There must be a meeting agenda and a leader whose job is to keep the meeting on track.
2. Ancillary subjects that come up should be recorded and listed as a discussion item for another meeting, or maybe even different people.
3. Often 5 to 7 people are recommended as maximum meeting size for most problem-solving sessions. Often this is impractical, but perhaps sub-groups can take on particular issues without using everyone's time.
4. Blaming, anger, belittling, fist pounding, yelling and other intimidation behaviors are not to be tolerated. If it gets to that point consider a cool down recess period, or temporary expulsion of the offender(s) to get the meeting back on a professional level.
5. Managers need to be particularly aware of the intimidation they have on those reporting to them. If you want honest answers, rarely should someone more than 1 level above the attendees be in the room. People will naturally say what they think the higher ups want to hear, not necessarily what they need to hear.
6. If there are multiple levels of managers in the room, people in the lower levels are not privy to how the managers have filtered any previous information between them, and thus the lower level of the hierarchy are very conscious of potentially contradicting their direct report manager. This may not be a problem if there is a high level of communication and trust on the project.
7. Sometimes very large meetings occur when several teams of people are involved. See the example below to see how that should be handled.
8. Meetings should close with a summary of what was discussed, any decisions, and any action items with responsible people and deadlines to report back.

Some common meeting incidents that cause a loss of trust and should not be tolerated.

1. Just before a planning meeting, send an informational package to another group. Then in the meeting announce that your deadline has been met and it is the other group's problem that it hasn't been completed yet. Always be honest and at least admit that you just sent it an hour ago.

Sometimes a small-impromptu meeting is all that is needed to work out issues. If decisions are reached, be sure to document and credit the other person with their cooperation and assistance.
If you are making suggestions in larger meetings that are based upon other people's input, be sure to credit them. It clearly shows respect, and you are almost certain to have their cooperation in the future.

2. Realize that you have just found a particularly thorny issue and lay it out there with no suggested solution, and implying others are to blame for this mistake. This is known as throwing the grenade. This is a particularly egregious strategy if done in front of people from different organizations. If possible, lay out the problem to the responsible people privately prior to the meeting, and try to develop some ideas for solutions. No one wants to be blindsided with bad news publicly.
3. Bring up problems without solutions. This does not mean that a solution is completely developed and ready to be implemented. It may be as simple as, "We recognize this is a problem, and we intend to talk to these people to try and find a resolution", or perhaps "This is not something we can resolve easily on our own. We suggest a task force with these groups to get us on the right track again." Or even "We could take this path, but we are open to suggestions from everyone."

This is a conference meeting where there is a clear hierarchy. People not at the table are not really part of the meeting to contribute unless called upon. Probably appropriate for this Senate caucus meeting, but rarely appropriate in a Project teamwork meeting.

MEETING EXAMPLES

1. **Intimidation By Meeting Size & High-Level Management**

A review meeting was scheduled at a skid fabricator's facility to look at the nearly completed equipment skids. The fabricator and design engineer had large contingents, along with representatives who were there to check on interfaces with their mechanical and electrical equipment. In all there were over 50 people from designer and craft levels to vice-presidents of various organizations.

After some preliminary discussions everyone went to examine the skids. When the meeting was reconvened comments were requested. The higher ups spoke up first attesting that everything looked good. Unfortunately, those at the design level saw obvious flaws that needed to be corrected. They were intimidated to say anything to avoid contradicting their bosses. Likewise, they did not want to embarrass the fabricators when a simple private conversation would have led them to the corrections.

When presented with such situations, the lead person for each organization should get positive and negative feedback from every person before they think they know the answers. Ideally technical teams should have been split up by disciplines with the fabricator counterparts and reviewed each skid carefully and taking notes.

2. A POSITIVE APPROACH TO LARGE MEETINGS:

At a large chemical operating facility, the plant manager was looking for ideas for improvements to safety, reliability and production. An experienced facilitator was brought in to lead the meeting.

Brainstorming is particularly susceptible to intimidation and peer pressure unless it is clear that all ideas are accepted, and the goal is to develop innovative ideas. This should never be facilitated by a Manager of a group that is involved. Even with the best of intentions, the hierarchy will cut off discussions before it starts.

This does not mean the manager should not be involved. The manager should develop the goals of the brainstorming, determine (or at least approve) the attendees, and let everyone know what is expected of them. This particular session had about 50 participants, which is unusually large. Sub – groups split out for specific topics.

Probably the most important point was at the beginning. The Manager welcomed everyone and laid out the purposes and goals for the session. He emphasized that he expected a large number of new ideas. Even if the ideas seem impractical at first glance, put them out there and see what happens. The next point was that he was looking at this as a team approach and everyone needed to participate whole heartedly to make this successful. He was going to leave before the session started and would probably never know who came up with which ideas, and he didn't want to know. He explained that whatever ideas the team rated as most important, would be acted upon by management. He could not promise all would be implemented, but he did promise an open answer on why each idea was being implemented, postponed or deferred. He wanted the team to be the successful entity. With that he introduced the facilitator and left the meeting.

The manager made an appearance at the end to thank everyone and re-promise responses to the team's highly rated ideas. In the end, many of the participants were put on task forces to implement the ideas.

Large problem-solving meetings can work, but as with the smaller meetings, they require a development of trust and respect. As with all problem-solving meetings, it required follow-through and an appropriate transparency that showed each person's effort mattered.

6.0 TEAM SAFETY

In the early 1970s before the Occupational Safety and Health Administration (OSHA) was organized, some of the only safety data available was deaths per $ millions of construction costs. It was basically assumed that if there were a $10 million project, a few people would probably die getting it built. We have come a long way since then with many long-term construction and operating projects going years with little or no lost time injuries and certainly no deaths.

With this kind of team improvement, it may be lost on many what incremental changes have been made to improve safety, and what may be left. Some of the major components of successful safety programs have been:

1. Coordination of work between multiple groups

2. Greater planning of work
3. Enforcement of basic safety rules such as Lock Out Tag Out, Confined Space Entry, and required safety equipment
4. A push by management that if ANYONE sees something that does not seem safe, they have the authority and responsibility to intervene until it is safe – a great example of focusing on team results, not individual results.
5. Process Hazards Analysis (PHA) on many types of plants bring experts together to consider anything that could go wrong that would affect safety.
6. Management of Change process after PHA has been completed to avoid making a change that invalidates the PHA.
7. Safety meetings before major and even minor tasks
8. Safety analysis after an incident or a near miss

From a design viewpoint there are also safe practices that must be implemented:

A. All design code requirements for each engineering discipline. These may be national codes issued by ASME, AISC, and other organizations, local, codes and state requirements.
B. All OSHA rules for the facility
C. Any Owner requirements for safety that are specified for the final product.

The regulations and rules are a good starting point. But regulations are always limited as they never cover every conceivable issue that may be in a facility's design. It is important that each team should consider safety from the beginning of design layout through detail design and construction from a personal viewpoint.

"Think of design safety as if you personally will be working in that plant someday. Will you feel safe being in the areas you helped design?"

Every facility will be the workplace for some people. They must live with any of the risks that are inherent in plants and they want to always go home safely. It is the responsibility of the entire team to make the facility safe for them.

ALWAYS CONSIDER SAFETY IN ACTIONS & WORDS

incident 1: Show You Care About Safety

A 4000 psi, 1015^{0}F steam line was inspected at an operating power plant and had anomalies that was concerning to the long-term integrity of the pipe. Given the size, temperature and pressure, a major failure of this pipe could be deadly.

To be safe, management agreed to shut down and replace sections of the pipe. Bill was on site to provide technical expertise and coordination of the replacement. All of the permanent plant personnel were well aware of what was being replaced and why. They would pepper Bill with questions in the elevator or hallways about the progress. Generally, the answer was, “We are proceeding well and will get it back online when it is complete and safe to do so.” However, at the end of a particularly frustrating morning Bill gave the curt answer, “We’re doing the best we can!”.

An hour later the Plant Manager called Bill to his office for an explanation of the rumors around the plant that the pipe replacement project was not being handled properly. He rightly noted that all these workers were really asking Bill was, “Is this pipe going to be ok? I don’t want to die working here.” Bill developed a new answer that has been truthful and served him well since then. “When the plant is started back up, I will be here to make sure everything is ok.” The plant staff wanted to know the coordinator took the safety and integrity of the equipment as seriously as they did.

Always consider safety from a personal viewpoint. It focuses you on the important safety issues, and you never know when you might be walking around the facility you helped design or build.

Always consider safety from a personal viewpoint in design and field work. Knowing these 2 pipes against the stairs are operating at 1015^{0}F, would you be comfortable climbing the stairs? Perhaps, but you would be cautious about grabbing the handrail.

Safety Example 2: Would You Do What You Are Sending Other People Out To Do?
A heater drain system was leaking under the insulation and the source of the leak was unknown. The pipe was up to 10' above the platform, requiring a 6' high scaffold to be built to remove the insulation and inspect. The system was pressurized to over 3000 psi and operating at about 400^{0}F. Three scaffolders were sent out to erect the scaffold. As they were installing the handrails, one of the rails hit a pipe elbow and released water that immediately flashed to steam. Two scaffolders were not tied off and fell 6' to the platform suffering minor bruises. The third was tied off and could not escape. He was severely burned and remained in the hospital and rehabilitation for over a year.

Going back to the proper engineering approach plant personnel knew:

1. There was a leak
2. It was a high temperature, high pressure line that could injure or kill if fluid were released
3. It was assumed the leak was in a flange or valve gasket that could be repaired, or at least controlled safely.
4. The plant could operate without this system but would lose some of its capacity for a few hours while it was shut off and cooled.
5. It was concluded that it was safe to approach the pipe because there are leaks all the time at power plants, and rarely is anyone hurt.

   The conclusion was a big mistake because the leak was not a gasket, but a severely eroded elbow. Once the scaffold pole hit the paper-thin elbow, it changed a limited leak into a catastrophic break. Some of the lessons learned include:

A. Personnel were complacent about the dangers
B. No real thought was put into what the possible danger was.
C. No inspection, such as from a thermal gun was performed to identify the possible source(s) of the leak

D. Management did not want to temporarily de-rate the plant to make the situation safer. In hindsight this decision is peculiar since any repair work would have required taking the leaking piping system out of service.
E. The workers who were told to build the scaffold were probably unaware of the danger they were being placed in.

7.0 BEHAVIORS

7.1 EGOS, KNOWLEDGE AND EXPERIENCE

Almost none of us like to have our work checked and corrected, but it is a necessity in trying to make our drawings and documents as accurate as practicable. We all have our egos, pride of authorship, and our desire to show our knowledge and experience. When accepting critiques from others, or performing the checking of others work, be as professional as possible and not let the criticism become personal.

Engineering schools are proficient in teaching us the principles of engineering and how we can use equations and test data to create all sorts of devices. Often this leads to a little "know-it-all" attitude in young graduates. However, the author has never met a young engineer who at some time, suddenly realized that he/she doesn't know everything and must look for advice from others.

Recognizing the Value of Others Knowledge Example:

For the author, the realization of the rest of the team's expertise came when designing a detail of a 12' diameter cylinder for a nuclear reactor. A very small tolerance was specified that would assure it would work properly. However, a few minutes after giving the sketch to the lead designer, the designer called the author over and informed him that our company owned the largest most accurate lathe in the world, and that tolerance was impossible.

Whoops! Fortunately, the mistake was caught quickly by the designer. A work around was quickly found, but the lesson was clear to the author that other people know important things. If the unworkably low tolerance had not been caught by the designer, this might have made it to the fabrication floor with the crafts having another chance to say, "We'll build it, if your drawing shows something that could be built."

7.2 HOW TO ASK THE RIGHT QUESTIONS

Once the concept is understood that many people have information that is useful, the logical step is to get that information efficiently without taking excessive time to identify and solve problems. This is far more difficult than it may appear on the surface. Based on the author's experience, it is primarily dependent upon the leaders of the project to solicit opinions from the correct people, letting everyone have their say, and then as a team develop action items to resolve the issues. The process must be respectful of everyone involved, open to some "thinking aloud", but then knowing how to keep the discussion from going down "rabbit holes" and wasting time and energy. The best managers know how to do this without coming across as an autocratic dictator.

It is important for each team member to ask questions about any issue that concerns them. Don't let it go, assuming everyone else has thought about it and knows the issue is solved. Maybe others are also hesitating to ask, and a major issue has been missed. Maybe you are looking at the issue through a different prism and a simple modification needs to be made. If you are intimidated to ask in a large formal meeting, ask a peer or more experienced person in a more private setting. At the absolute worse, your question can be answered by a team member and you learned something useful to you in the future. At best you helped avoid a major problem.

There is an important caveat to asking questions and getting answers. Once an answer has been provided, accept it and, learn from it and move on unless there are still serious concerns that need to be explored. See Example 1 below.

Question and Answer Examples

1: Accept Well Thought Out Answers:

When a demonstration plant for producing electricity by using mirrors and the sun to produce steam was being designed, Ron was borrowed from the petrochem division to complete the drawings. Ron said he had been taught that spring and constant support hangers should never be used on a pipe rack and insisted we had to re-design the facility. The lead piping designer, lead piping

Solar One
demonstration

engineer, and the discipline manager all took his concern seriously and explained why the design was appropriate and had been carefully analyzed. Unfortunately, Ron continued to complain daily, with no reason except that he had been taught that was the wrong thing to do. While his tenacity and desire to want to do the right thing were admirable, his inability to accept that other people know important things was a barrier to his learning and improving. When confronted with new facts and explanations, learn from it and accept.

2: Root Cause Analysis Study
A critical pipe had a through wall failure causing a plant shutdown and a significant loss of revenue until it was repaired. Clearly the Plant Manager was under a lot of pressure from corporate management and after the repairs were completed, convened a Root Cause Failure Analysis meeting with operators, engineers, and maintenance personnel. A proper first step.

Then the Plant Manager opened the meeting with the statement, “I have only scheduled this meeting for 1 hour and at the end of it I want to know who to blame.” Clearly not the right statement. People are defensive when investigating a failure that occurred during their watch and telling everyone the “knives are out” usually guarantees the correct resolutions will not be achieved.

The Plant Manager’s opening statement should have been, “We had a significant failure that we can’t afford to repeat. Now let’s go over what happened to the best of our knowledge. We’ll assign tasks to resolve the things we don't know. When that is done, we need to come up with short term and long-term action plans to minimize these types of failures."

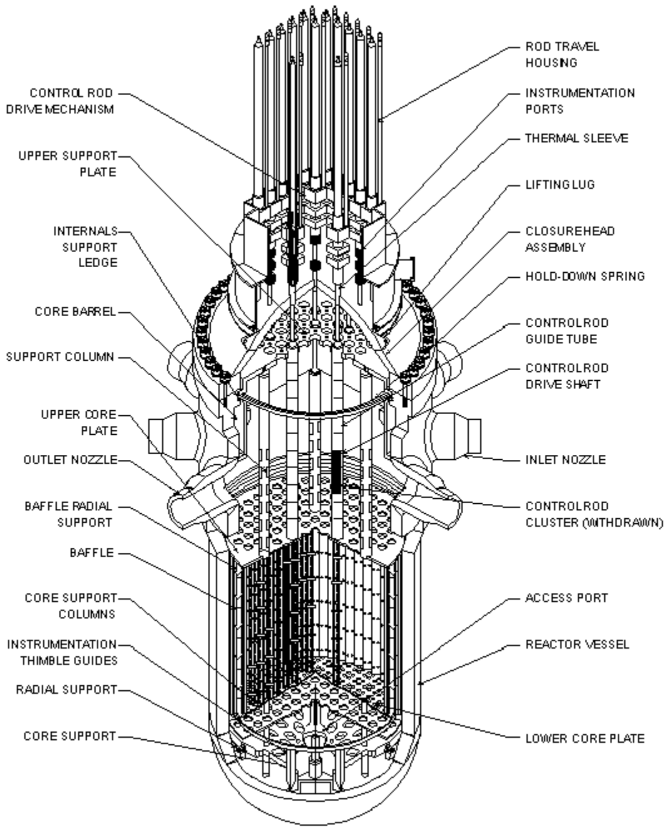
Fortunately, the people in the meeting were experienced enough that they took the professional approach as soon as the Plant Manager left. The failure was identified as caused by a design error and sliding supports that did not slide. Corrections were made and NDE inspections expanded to include a number of other suspect areas. Corporate Management was not impressed with the Plant Manager's approach and let him go. Sometimes the first one to pull out their knife loses.

3: Ask the Right Question & Listen to Others

During Hot Functional Test of a nuclear reactor, several components failed and literally broke loose, creating a 9-month intensive analysis, testing, redesign and rebuild to correct vibration issues. [Note 2]

One of the improvement ideas was to install some accelerometers at various locations around the reactor loop and hook them up to a speaker in the control room. The theory was that if a component ever broke loose again, the operators would hear the banging and know there was a problem they should fix. Not very sophisticated, but this was back in the 1970s. The device was dubbed the LPM or Loose Parts Monitor – while an accurate moniker, it was poorly named since there should never be any loose parts to monitor. If we did this today it would have a positive name like Integrity Assurance Monitor.

The LPM worked! A few months after full operation the operators heard something banging around in the bottom of the reactor. The designers of the LPM were dispatched to the site and recorded the vibration signature of the loose part hitting instrument tubes in the bottom of the reactor when the pump was "bumped" for a second. To most people, the question was "What is it? Nothing should be loose in the bottom of the reactor." The LPM team strongly recommended immediately unloading fuel and retrieving the part and determining how much damage had been done.



A Pressurized Water Reactor cut-away view. Loose part was in the bottom below the fuel and core support..

However, the owner was interested in restarting within a couple of days and did not want to shut down for 2 or 3 weeks to unload and reload fuel. **The Owner's question was "Is the loose part big enough that it will not be lodged in the nuclear fuel and create a hot spot?"** It was clearly the wrong question from a safety and reliability standpoint. To the Owner, it was the correct question for maximizing revenue, and was the only question the Owner wanted answered.

With some vibration signature analysis, it was determined that the loose part was too big to get lodged in the fuel, assuming pieces did not start breaking off. The utility restarted the unit, and a couple of weeks later the unit had an emergency scram and safely shut down. One of the Reactor Coolant Pumps (RCP) had seized.

Upon investigation, the loose part was the hub bolt for one of the RCP impellers. Two of the three other RCP's had loose hub bolts. It took 6 months to repair the seized pump and get the plant back on-line, when it probably could have been done in a month if they had investigated the problem more thoroughly at the time. With hindsight, the correct question of resolving what the loose part was and fixing it, would have also been the Owner's correct question to maximize revenue.

4: Politics, Money & Lawsuits – A Recipe to Destroy Any Possible Teamwork:

In Texas the power grid failed in February 2021 during an unusually long-lasting cold snap. Immediately, politicians blamed the reliance on wind turbines that froze, others blamed Texas's nearly self-contained power grid with few lines to the rest of the nationwide grid, others blamed the free market power generation operation, others blamed the grid operator, ERCOT, for mismanagement, others blamed the generation plants which were not properly winterized, others have blamed the natural gas suppliers who could not get gas to the electric generating plants and the gas plants blamed ERCOT for cutting off their electricity which forced them to shut down their pipelines.. This is an extreme example of jumping to the conclusion that some people want so that they can get the solution they want or avoid blame, instead of asking the right questions. In this particular case there are very high monetary penalties on some companies. At the time of this writing, the result of this finger pointing is not known. Very few people and organizations seem to recognize (or at least willing to accept) they are part of a team that should be trying to understand and fix the unreliability. At the time of this writing, it appears highly doubtful the best solutions will be implemented.

While these examples may seem extreme, they are fairly common examples of what can happen. Pressure from above to keep plants running, pressure to blame others to protect one's own job, internal ego to not learn from others, pressure to avoid legal liabilities, pressure to preserve an image of a corporation, pressure to protect corporate turf, and other motivations can lead to poor solutions.

7.3 SCIENTIFIC PRINCIPLES SHOULD NOT BE ABANDONED

The methods to solve these problems are difficult in some cases, particularly when high powered politicians and companies have vested interests in their own agendas. When teamwork is not apparent, we should not contribute to the chaos. All each of us can do is to use scientific principles to properly address each problem.

1. What are the known facts?
2. What are the additional facts we want and need to know?
3. How can we obtain more information?
4. If the information is unobtainable or too difficult to obtain in a reasonable cost and time, what assumptions can be tested? The less that is known the more likely wrong conclusions will be made.
5. Given all the information available, what are the possible conclusions?
6. What are the risks to safety, reliability, performance and other important factors if any of the assumptions are incorrect?
7. Given these conclusions, what are the reasonable recommendations?

These steps are written generically to address a myriad of issues in design, construction, operations, maintenance and failure analysis. Safety, reliability, performance, potential of cascading failures, and other issues may be the driving definition(s) of reasonable. The point is to stay focused on the right questions, answer with facts if possible and identify assumptions where they are made. Avoid as many of the outside influences of money, turf, politics, and one-ups-man-ship as possible. You succeed as a team or fail as a team.

It is important to know that almost never is there a situation where everything is known that needs to be known. Additional calculations, tests, inspections, research and assumptions are almost always involved. Sometimes you find a very similar issue that another group of people had to solve. This can be very helpful but beware the differences between your issue and the one that others solved. There may be a difference in temperature, pressure, fabrication or other detail that does not apply in both cases and leads you in the wrong direction.

8.0 CONTRACTING METHODS

A short discussion on contracting methods for a new plant or equipment. The general method is a specification, leading to a fixed-price, or cost-plus project. Each method has its benefits and risks, particularly in terms of controlling the final cost of delivery. In this course, we will focus on the effects of teaming for each type of project.

In a fixed price contract, there should be a very detailed specification prepared by the Owner that explains exactly what is expected. If the contract is fixed price turnkey, meaning Design and Construct for one price, the engineer and contractor will be unwilling to listen to any change requests without price adjustments. The team of the engineer and contractor is probably very strong in this scenario. But the Owner with operating, maintenance and performance goals to meet is basically left out of the process until the plant is turned over at completion. Teamwork is likely to suffer. There is one team that develops the product, and a completely different team that must live with the results. If the product is something that has been built many times and the Owner has been happy with the results, then perhaps this process works. But in the worst case, the Owner spends years attempting to get the plant into serviceable operating condition.

In a cost-plus contract the Owner is typically involved in the design and construction process and is more likely to be able to influence the product to meet its desired goals. This influence is limited by the fact that many of the requirements must be written in the specification and adhered to in the initial plant layout. While some corrections can be made at 30% and 60% design reviews, major decisions are made early in the process and can be very expensive to change later. From the Owner's perspective it is critical who in their organization participates in the design process. They must be well informed and good communicators with both the design team and the Owner's organization. It will be their insistence that will assure the product is built properly, and likewise the cost of the project can mushroom if they are not reasonable in their requests. Unless a Contractor is brought in early in the process for review, Constructability will probably not be a high priority in this scenario.

CONTRACT EXAMPLE

1: Duplicate Units

Build Unit 2 as an exact replica of Unit 1 and we will pay you 40% of the engineering cost charged for Unit 1. Sounds reasonable, but then, are they side-by-side or mirror image units? What are the interconnects of piping, structural, electrical and control systems between the units? Will there be two control rooms or are both in 1 unit? What about auxiliary building and services? Have regulatory requirements and design standards changed since Unit 1 was started? Was there anything that you would want changed from

Unit 1 when Unit 2 is built? And a myriad of other details may come up.

In the 1970's an E&C company had signed such a contract. On Unit 1 a major interference of structural steel and pipe was such a problem that it took about 6 months to resolve after being discovered. As Unit 2 design was started, those on the design team thought that a better solution could be made to the problem, but were prohibited to do it by the Project Manager – until the Owner agreed to a cost extra for engineering. Even when the engineering seems straight forward, money and contracts may get in the way.

2: Fixed Price Turnkey Mess

A major power plant was built in Texas on a fast track Fixed-Price Design-Construct contract. The plant was completed on time, but the quality was exceedingly poor. Within two years coatings were failing and structural beams were severely corroded, some coal silos were built without tops allowing coal dust to go everywhere, and even some major tanks were in danger of failing because the 54" diameter pipes were supported by the thin tank wall, not by structural steel.

There were many more problems, and the original contractors just responded with words such as "It was built per the contract and you accepted the product." The Owner was just trying to get the facility built quickly for a fixed price and did not even take the opportunity to have its experienced operators and maintenance personnel help write the specifications, or review drawings. Literally 5 years and tens of millions of dollars were spent attempting to get the facility to an acceptable level for reliability and safety.

This is an extreme, but not unique example of what happens when the Owner does not participate as part of the team.

9.0 SUMMARY WITH THE "NEAR PERFECT PROJECT"

By far the best run project that the author ever experienced was a design-build plant for a pulp and paper company. The contract for the engineering & construction company (E&C) was clearly laid out with detailed requirements important to the owner, and an aggressive schedule for completion. The unusual aspect was that the base price was basically break-even for the E&C. Significant bonuses could be earned by meeting the quality and schedule requirements of the contract. The E&C kept half the bonus and promised everyone who worked on the project the other half of the bonus, split between individuals based upon their number of hours worked, and their salary. The potential was there to add 50% to a person's normal hourly rate.

The level of teamwork was extraordinary. No one wanted to be the person to put everyone's bonus at jeopardy. If anyone had an idea for improvement, it was listened to. If anyone found an error, it was corrected quickly. If anyone had a question, management made sure it was answered properly. Complaining, back-stabbing, rumor mongering and other destructive behaviors were not tolerated by peers.

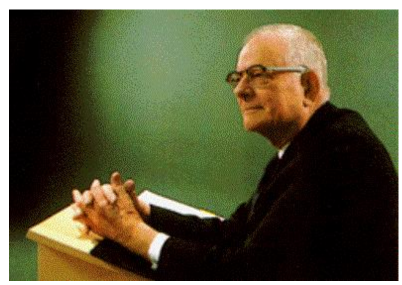
It would be nice to say that every project performs so well, but the promise of significant bonuses to each individual overrode all of the common issues that limit the teamwork on a project. Management was well focused, and each individual stayed focused on the important issues.

Can this same level of teamwork and cooperation be duplicated on other projects? It should be possible with strong management that wants and fosters teamwork. There are many obstacles, but if the desire is for high quality and predictable results, each team should be attempting to match the "Near Perfect Project." Keep these principles in mind:

1. **Virtually all engineer's work is a team effort, even if you never meet some of the team members**
2. **Communication between disciplines, and between design team, suppliers, contractors, owners and other stakeholders is the single biggest key to a successful project.**

3. **Everyone in a team has something to offer. Do not stifle their ideas or hold back from presenting your own.**
4. **Managers can make or break the teaming relationships by their behavior.**
5. **Too much high-level management can stifle ideas, even when the manager's intentions are benign.**
6. **Projects should be organized and scheduled to allow continual communication from concept to completion between the design team, owners, suppliers, contractors, operators and maintenance personnel. The level of interaction will vary throughout the process, but long-term respectful relationships are the best predictors of a successful project.**
7. **Ask the right questions.**
8. **If you ask a question, there are two possible good outcomes.**
    1. **You have found an issue that needs to be addressed.**
    2. **The question is answered satisfactorily, and you learned something that will help you in the future.**

NOTES:



1. W. Edwards Deming was an American statistician who is credited with helping Japanese businesses develop Total Quality Management during the 1950's. In 1990 the author attended one of Deming's seminars in Houston, Texas. He was making a point that since management owns the design and process of making a product, places the people in their roles, and trains them; his studies found that management is responsible for around 80% to 90% of the production errors. He then finished with the statement as remembered by the author as "No one gets up in the morning and says, I hope I can do a really bad job today." He wrote several books on quality which are still applicable today.

2. The Hot Functional Test was performed in 1972 before nuclear fuel loading and was intended to assure that the pumps, instruments and other components would perform properly. Thankfully all these problems were properly redesigned and repaired before the fuel was ever loaded. The plant and its sister units have performed well since then and are still in full operation in 2021.

