DESIGN MANAGEMENT: RELIABILITY AT THE START

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INTRODUCTION

Design management for installations and modifications to plant systems and equipment should go beyond engineering calculations, bids and drawings. While the engineering is important, items related to reliability and maintainability are sometimes treated as afterthoughts. To reduce the chance of premature failure and frustration and reduce the unexpected, a Design Management Program should be implemented and enforced. The Design Management Program should place an emphasis on reliability and maintainability with participation from all levels of the plant including engineering, maintenance, operations, safety, and purchasing. The program should also establish the review process with an incremental methodology. All design projects, whether capital or non-capital require the same methodology for inputs and review. Of course the larger the project the longer the process so enough planning time should be allowed, often a year or more in advance of the actual installation start date.

DESIGN REVIEW PROCESS

The design management process is led by a Project Manager who acts as planner, coordinator, engineer, and team leader. The selected Project Manager should manage the project from start to finish. Often Project Managers are managing several on-going and planned projects at any given time. Project Managers can be selected from any area of the organization; however, typically the plant engineer will manage most large projects.

DESIGN TEAM

The Design Team is made up of participants from all areas of the plant's organization. As stated earlier, this includes but is not limited to engineering, maintenance, operations, safety and purchasing. Every team member is assigned responsibilities by the Project Manager during the project kick-off meeting. Communications amongst the members is paramount for success of the project. Table 1 describes a sample Design Team with some general responsibilities.

Department	Participants	Responsibilities
Operations	Production Manager, Production Superintendent, Process Engineer, Production Supervisor	Process issues, operating instructions, operating manpower, operations training
Maintenance	Maintenance Manager, Maintenance Superintendent, Reliability Engineer, Maintenance Supervisor, Maintenance Planner	Maintainability, accessibility, maintenance strategies, parts strategies, equipment hierarchy and criticality, maintenance manpower, predictive maintenance baselines, maintenance training
Safety	Safety Manager	Safety issues, accessibility, ladders, catwalks, possible hazards, warning signs
Environmental	Environmental Engineer	Environmental issues, permits, hazardous waste, waste water
Engineering	Plant Engineer, Design Engineer, Architect	Project management, engineering calculations, drawings, economic evaluation, life cycle costing
Purchasing	Purchaser, Parts Clerk, Buyer, Contract Manager	Parts procurement, contracting, inventory assessment
Human Resources	Training Coordinator	Research and schedule operations and maintenance training

Table 1 General Design Team Responsibilities

REVIEW PROCESS FLOW

Design projects generally go through several reviews prior to issuing a final design package. A conceptual, several preliminaries and a final review are typically performed. The conceptual design may be used as a basis for an idea or in preparation for a capital budget request. Normally, there is only one conceptual design. Preliminary designs are the most numerous and time consuming depending on the complexity of the project. These preliminary reviews may or may not include all of the team members depending on the purpose. For example the reviews may be designated by discipline such as mechanical, structural or electrical designs. These reviews are decided at the kick-off meeting while assigning responsibilities for input. However, all of the team members shall participate in the final review process. Figure 1 shows a typical design review process flow.

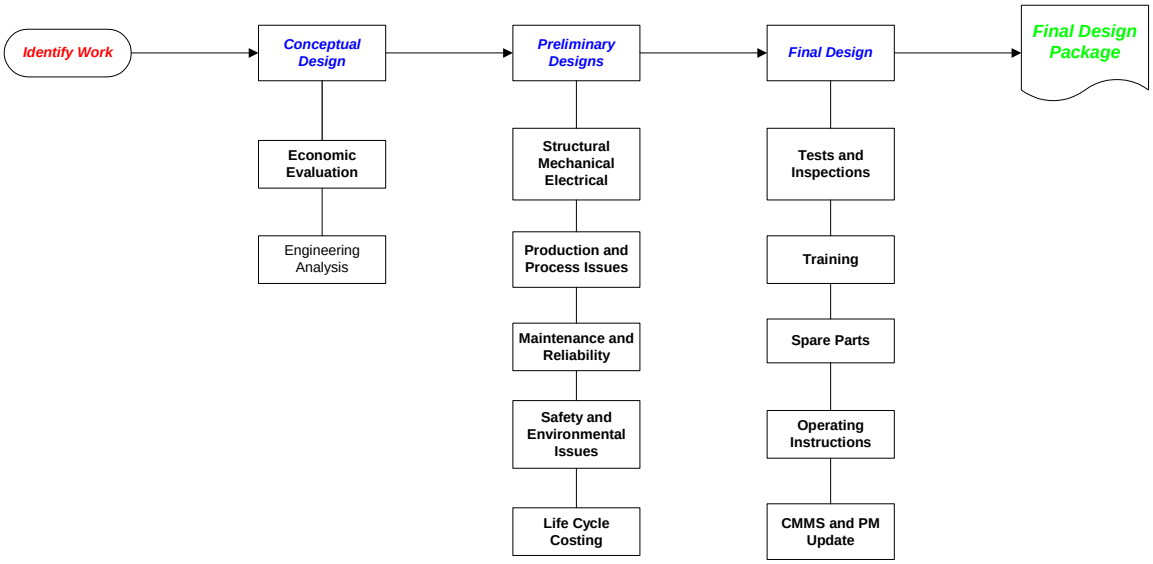

Figure 1 Typical Design Review Process Flow

PROJECT TRACKING

Now that we have established a Design Team we can concentrate on how to manage the design process. There are numerous software packages out there for tracking projects. Most of them require a certain degree of training in order to be utilized effectively, without taking up all of your time in setting up each project. A simpler method is the use of a simple checklist in MS Excel. The simpler method will be sufficient for large and small projects without an extensive amount of set-up time and will be easily understood by all members of the Design Team. Table 2 shows a sample tracking spreadsheet. The type of tracking documentation is not important, but using some form of tracking documentation is.

Design Management Checklist Page 1								
Section 1 Process Requirements			Completion Dates					
Item	**Responsibility**		**Conceptual**		**Preliminary**		**Final**	
			Required	**Actual**	**Required**	**Actual**	**Required**	**Actual**
6.2.1.2/6.2.1.4 Economic Evaluation								
6.3.1.1 Identify Installation Interfaces								
6.3.1.3 Identify Process Requirements								
6.3.1.3 Identify Work Force Limitations								
6.3.1.4 Identify Safety Requirements								
6.3.1.5 Identify Environmental Limitations								

Table 2. Sample Tracking Spreadsheet

COMMUNICATIONS

The importance of Design Team communications cannot be over emphasized. Regular meetings, phone conferences and even E-mail can be used for the purpose of requesting inputs and acceptance of the design elements. A kick-off meeting scheduled in the beginning of the design process will be used to define the ground rules for communications. While face to face meetings are usually very productive, and provide the Project Manager with on the spot decision making, they are sometimes difficult to schedule with a large or geographically separated Design Team. The use of electronic documentation makes E-mail a very efficient method of design review, but does require a very diligent Project Manager, to follow-up on the information required. Phone conferences are productive only if everyone has copies of the documentation to be discussed. This may require the use of electronic media, fax or express mail depending on the type and amount of data. Any scheduled meeting should have an agenda should be provided to each participant to avoid surprises and delays.

DOCUMENTATION

Whenever you deal with multiple members of any team, documentation becomes an issue. Everyone has their own ways of doing things and documentation is no different. The Project Manager must organize the information being provided in a way that can be utilized by the whole team. Setting up a spreadsheet with worksheets for each of the areas of concern such as engineering, tests and inspections, maintainability etc. is an easy way to organize the data and allows electronic distribution as well. In some cases a notebook will be used with all of the required documentation kept together. This paper data can later be scanned and put into files for storage after the project is complete.

TESTS AND INSPECTIONS

Many plants insure that adequate testing is accomplished during the commissioning of a new system or major equipment installation. While this testing is important, in-process testing should also be considered. In-process tests and inspections are performed at various stages of the project and may also include other locations including vendor or manufacturer sites. In addition to the identification of adequate tests and inspections, a specification and documentation methodology must be developed and enforced. This planning is done during the Design Process.

IN-PROCESS TESTS AND INSPECTIONS

In-process tests and inspections, start at the manufacturer's site, and may include visual inspections, measurements, alignment, NDT, pressure testing, performance tests and others. Typically, in the past, most plants have relied on the manufacturer or vendor to specify these QA requirements and accepted results based on criteria not set by the plant. The Project Manager with the assistance of the Design Team should specify all test and inspections required to reduce the chance of early failure of each new or rebuilt component. Manufacturing flaws should be identified and corrected as early as possible, not during the commissioning testing. In some cases, a representative from the plant should be at the manufacturer's site to witness the test and inspection process to insure compliance with specifications. Witnessed or not, documentation should be provided for all of the tests and inspections performed.

This same theory applies to receipt and installation testing. When a new component arrives at the site, a series of inspections should be performed to insure damage has not occurred in transit. In the case of rotating equipment, at a minimum, a visual inspection and free rotation test should be accomplished. During the installation process, tests and inspections may include visual inspections, measurements, pressure testing, NDT, performance tests and others. With the introduction of

predictive maintenance (PdM) technologies such as vibration analysis, ultrasonic testing, infrared thermography etc., many tests and inspections can be accomplished in much shorter time periods and with more accuracy that in the past. While these test and inspections are important, the documentation of results takes center stage.

COMMISSIONING TESTS AND INSPECTIONS

The commissioning tests and inspection results depend largely on the in-process test and inspection success. This is the time for setting up baselines for the PdM technologies to use as a reference for future monitoring of performance. In addition, new operating instructions are evaluated and operations' training is conducted.

OPERATIONS REVIEWS AND INPUT

The Operations Department is usually the customer who will accept the new system, process or component when installation is complete. Therefore, it is their responsibility to ensure the desired level of production will be achieved without compromising safety or environmental requirements. Operations personnel are an important part of the Design Team and should be active in reviews, providing input from the onset of the design process.

PRODUCTION AND PROCESS REVIEW

Most new installations or major modifications will effect the production of product(s) one way or another. This effect could be a change in process, an increase in capacity or number of components. When reviewing the design, operations should be asking several questions. Will we need more manpower? Will we be producing enough for future markets? What kind of specialized training is required? Is quality being compromised? Are the present operating instructions adequate? This type of information and more, are important to insure the design will fulfill the needs of the plant.

SAFETY

How many times have you seen a poke hole or access opening with no catwalk or ladder for access? What about adequate lighting? Do you have enough warning signs? Many of these types of issues are normally found after commissioning and are not identified during the design process. Not only have hazards been created, but the changes required will probably cost more than if they were identified and made a part of the design package. The safety manager or representative should review whether the new system or equipment can be operated and maintained safely. In addition, certain situations may require specialized safety training. Remember:

"SAFETY SHOULD NEVER BE AN AFTERTHOUGHT"

ENVIRONMENTAL

Today's environmental regulations have multiplied tenfold over the past few years. Regulatory requirements and permitting have also increased. Don't wait until you are ready to fire up the kiln, or start up the assembly line, only to find out your permits are inadequate for a new process. By reviewing the design throughout the process, time will be available to investigate any potential environmental issues and obtain necessary documentation and permits.

As you can see the Operations Department should be extremely active in the design management process. Figure 2 depicts a summary of some Operations Department responsibilities.

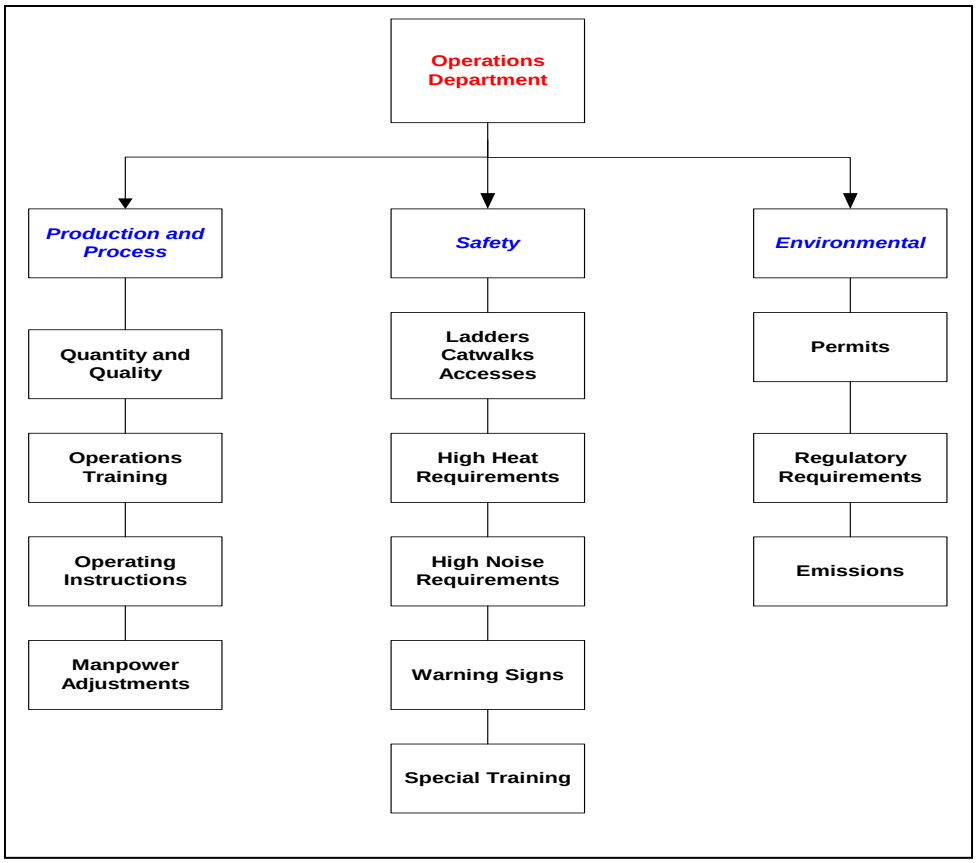

Figure 2. Operations Department responsibilities

MAINTENANCE DEPARTMENT REVIEWS AND INPUT

Reliability and Maintainability are considerations undertaken by the Maintenance Department. Reliability Centered Maintenance (RCM) techniques will limit early failures often referred to as infant mortality and also ensure adequate maintenance is scheduled for the future. Determining Maintainability will ensure the required maintenance can be scheduled and performed efficiently.

RELIABILITY

Reliability of new equipment and systems should be based on two basic elements of the RCM process, Mean Time Between Failures (MTBF) and Failure Modes Effects and Analysis (FMEA). MTBF is a methodology used to determine how long a system or component will operate before incurring a major failure. When specifying new components, the MTBF should be considered in order for the vendor to provide a product meeting your expectations. MTBF is normally based on the component's performance history in similar situations. Vendors and manufacturers will normally provide this information on request. MTBF should weigh in the procurement process as much as, or more than initial price.

FMEA is a more complicated RCM methodology used to determine what can be done to reduce failures of systems and components. The FMEA starts with defining criticality levels of the components and creating a hierarchy depicting interrelationship. The process then evaluates all of the potential failure modes and how they affect performance. This data is then used to determine methods or tasks to reduce these failure modes. We then develop maintenance and parts strategies which serve as a basis for Preventive (PM) and Predictive (PdM) maintenance, and spare parts identification. The same FMEA methodology is utilized to define the acceptance

tests and inspections described earlier. Once a failure mode is identified, the appropriate test or inspection can be performed to determine if the potential for failure exists.

MAINTAINABILITY

Maintainability is determined to consider if and how maintenance, as identified using RCM, can be accomplished. Factors such as location of components as well as accessibility will be considered. A PM task to do a visual internal inspection is useless, if the access door cannot be opened because the unit was installed to close to a wall. Sound familiar? We must also look at manpower requirements, so as to insure we have the hours and talent available to do the tasks. What good is maintenance if it does not get accomplished? In some situations the maintenance staff will require some equipment specific training or special certifications in order to complete the required tasks. This training must be identified, budgeted and scheduled in advance of commissioning. Another item that frequently is treated as an afterthought is special tooling. As with manpower, you have to have the tools in order to accomplish the tasks. The same goes for lifting pads and beams in strategic locations. Another factor to consider is being able to accomplish as much maintenance as possible without shutting down the equipment. This can sometimes easily be done with the addition of a redundant or portable system and the use of bypasses on components such as filters and heat exchangers.

Reliability and maintainability should be considered throughout the review process. Figure 3 describes some of the reliability and maintainability roles in design management.

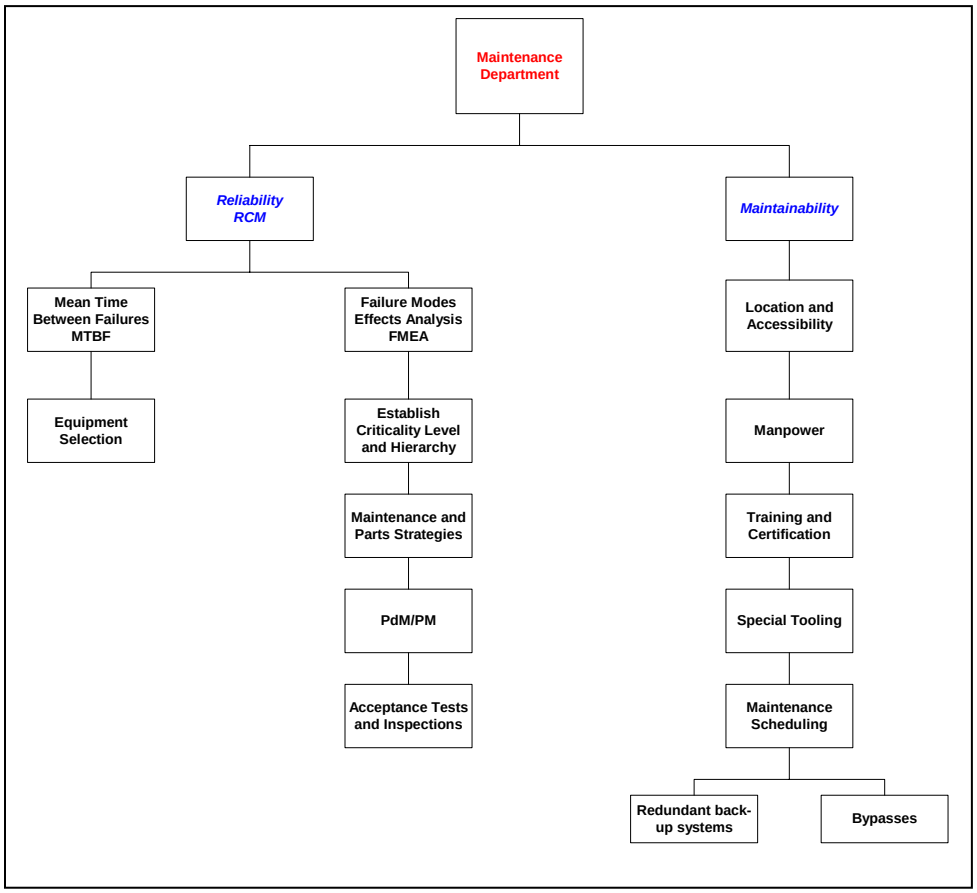

Figure 3. Reliability and Maintainability roles

ADMINISTRATIVE DEPARTMENTS

Human Resources (HR) and Purchasing also play important roles in the design management process. The contracting of services and parts rests with purchasing , while HR will research and schedule training for new systems and equipment.

LIFE CYCLE COSTING

In order to get the "Best Value" on the purchase of equipment or to investigate new versus rebuild, we must go beyond the initial cost. Total cost of ownership will allow managers the opportunity to make financial decisions concerning major projects in a realistic manner. Life cycle costing tools allow the comparison of this total cost of ownership between vendors or methodology. These tools may be used in the beginning, during the budget submission process for the project or during stages of the project requiring the purchase of major components.

SPREADSHEETS

A talented person with MS Excel experience can develop a spreadsheet to be used for life cycle costing for comparison purposes. Items to be considered include initial costs such as procurement, design and installation. In addition we need to add the on-going expenses such as operating, maintenance, fuel and labor, calculated over the estimated life span of the component. This will provide an estimate of the entire cost of ownership for the component. Other considerations will include salvage value and return on investment (ROI). ROI is an estimate of the value the equipment is adding to the plant over time. The biggest problem with determining life cycle cost is obtaining accurate data. If historical

data is available, the estimates are usually more accurate. Other sources of data include engineering estimates from various vendors or like equipment history. In most cases a little research into the sources of this data will make the estimating process more accurate. Something as simple as a phone call to another plant or reading some equipment reviews on the Internet can be invaluable for this process.

SUMMARY

Design management is a team effort with dedicated team members led by an experienced Project Manager. If effective communications are established and all of the team members understand their responsibilities, the effort will result in a much more organized and reliable endeavor. Remember the key elements to equipment reliability:

DESIGN IT RIGHT

BUILD IT RIGHT

INSTALL IT RIGHT

OPERATE IT RIGHT

MAINTAIN IT RIGHT

