
Managing Plant Turnarounds and Outages

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Daniel Daley, P.E., CMRP



Continuing Education and Development, Inc.
22 Stonewall Court
Woodcliff Lake, NJ 07677

P: (877) 322-5800
info@cedengineering.com

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By

Daniel T. Daley

Introduction

For those who work in refineries, chemical plants and power plants, every few years it is necessary to shutdown each of the operating units for a major activity that is called a Turnaround or Outage. The term “turnaround” is more commonly used in the refining and process or chemical industry and the term “outage” is more commonly used in the utility industry. For purposes of this discussion, I will use the one term, turnaround, and will further shorten it to TA.

With the exception of very large construction projects, a TA is the most significant activity that appears on the calendar of any of these facilities. An unfortunate aspect of TAs when compared to large projects is that they seldom happen every year so it is impossible to stay “in practice” with the procedures needed to make TAs successful. Also, unlike major projects, TAs are typically accomplished using the personnel indigenous to the facility for management, supervision and, at least, some portion of the direct labor. This usually places a significant strain on the plant resources during the period of preparation and execution.

The strain on resources frequently creates a temptation to minimize the preparation time and to limit the resource investment. As a result, TA performance is often less than is desired. Inadequate TA preparation leads to cost and schedule over-runs. Occasionally individuals respond to cost and schedule over-runs by reducing the scope so the plant is not as well prepared for the post-TA run as it should be. In other situations, the lack of TA preparation can lead to injuries or other safety problems as well as insults to the environment.

Organizations that perform TAs very well, have found that TA planning and preparation is an on-going activity that should have some attention and resource investment at all times. Even when TAs are long in the future, it is wise to have a small resource actively engaged in understanding the scope for the next TA and the things that might be done to ensure the up-coming TA is accomplished in an efficient, effective, safe and environmentally sound manner.

What is a TA?

Refinery units, chemical plants and power plants typically have a number of components that experience some form of deterioration over time. While it might be possible to simply “live with the deterioration”, ultimately, the deterioration would ultimately lead to:

- An unacceptable level of structural integrity
- An unacceptable level of reliability
- An unacceptable level of one or more forms of performance

Frequently, piping or other pressure retaining systems experience some form of corrosion during operation. As the corrosion deteriorates the pressure retaining capability, it also increases the likelihood of leaks and other events resulting from the leaks. There are standard practices designed to provide rational limits to the risk of failure. For instance, when piping systems reach the point of “half-life” or the point that one-half of the remaining corrosion allowance has been lost to deterioration, it is necessary to take the piping system out of service to perform an internal inspection. The internal inspection typically necessitates a plant TA, but it also provides a reasonable level of assurance that the deterioration due to corrosion is progressing at the expected rate and things have not changed for the worst.

Obviously, in the example above, if the piping system in question is only inspected and not replaced, the half-life of the remaining corrosion allowance will become increasingly smaller and smaller thus reducing the maximum interval between TAs. At some point, the continual shorting of the run-length between TAs will become unacceptable and the deteriorated piping will be replaced with new piping with a “fresh” corrosion allowance. In this example, it might also be possible to change the metallurgy of the corroding system (or systems) to materials not subject to corrosion. In this cause, the structural integrity or robustness is no longer a consideration in scheduling the TAs and TA interval and duration can be decided by other issues.

In a way similar to the deterioration of structural integrity of pressure retaining systems due to deterioration, the components important to the reliability of the system can deteriorate over time. The following are a few examples of the ways in which reliability of key components can be compromised:

- Vibration can result in deterioration due to fatigue
- Vibration can result in deterioration of electrical connections resulting in open or intermittent circuits
- UV or chemical attack can cause insulation on electrical components to crack resulting in shorts and grounds

- Seals and bearings in mechanical equipment can become worn making failure more likely
- Valve seats can become worn preventing a tight seal when closed
- Relief valves can become plugged with corrosion products or solidified process chemicals preventing their operation when needed

In these cases and in myriad others, it is necessary to clean or renew the components to ensure that their intended function is reliability accomplished in the future. In many cases, it is necessary that the entire operating unit be shutdown for a TA while the renewal is taking place.

In still other situations, the efficiency or effectiveness of a facility tends to degrade for a number of reasons over time and a TA is needed to restore them. For instance:

- The valve-caps mounted on trays in distilling towers in refineries and chemical plants frequently become fouled with debris over time and they need to be cleaned to restore optimum effectiveness.
- Another example are heat exchanges that become fouled over time. They require intermittent cleaning to ensure optimum heat exchange efficiency.
- Occasionally fixed-bed reactors or other equipment like dryers or molecular sieves lose activity over time and require renewal or recharging of their contents. Since these devices form part of the path the materials follow through the plant, it is necessary for the plant to be taken out of service when they are maintained.

While the three examples of situations requiring a TA are somewhat different, they also have some similarities. For each, there is a finite period of time between events in which they must be inspected or renewed. Those events require a plant TA. The shortest run-length between required inspection or maintenance activities determines the maximum run-length between TAs.

Each also require a specific period of time for the inspection or renewal to occur. In most cases the duration of the maintenance activities vary and the duration of the TA is determined by the longest string of activities.

What are the Objectives of TAs?

Each and every TA has a group of objectives that describe the results that should be achieved by the end of the TA. The following list provides a typical example of the objectives that are typically identified prior to each TA and then measures at the conclusion of the TA to determine if it was a success or failure.

- Safety – There is typically a goal in terms of the number of injuries or the OSHA recordable rate that is expected to be achieved by the workforce involved in the TA.
- Environmental performance – There is typically specific objectives concerning spills or other forms of environmental insult that must be avoided during the TA.
- Schedule adherence – Once the schedule is set, there is typically some allowance for foul weather or scope growth. If no foul weather occurs or the scope growth is smaller than provided by the allowance, the TA should be completed within the duration set by the initial schedule. If uncontrollable issues arise, the TA should be completed within the original schedule plus the allowance.
- Budget – As with the schedule, once the budget is calculated, there are typically two additions. The first addition is “contingency” and the second is “addendum”. The amount allowed for in the contingency and addendum can be as small as 5% and as large as 25% or more. The percentage allowed for contingency can depend on the time of year and the location of the work. A TA accomplished at a time and in a location where foul weather is likely to cause significant delays should be provided a greater amount of contingency. The addendum or allowance for added work should depend on how well the TA scope is known. For relatively new plants with which there has been little experience and for plants that have experienced a significant amount of unquantified damage, the addendum allowance should be quite large. Also as with the schedule, if untoward events, (foul weather or unexpected scope) do not occur, the contingency and addendum allowances should be returned to the budgeting authority unspent.
- Scope completion – all the work defined as part of the work scope should be completed during the TA. It is also important that no work that is not part of the approved scope be completed. The work that is part of the TA scope has been approved. As a result, it is planned, scheduled, budgeted and, if needed, properly engineered. Work that is not part of the approved scope has not been planned. It has not been scheduled. It is not covered by the budget. If it entails some form of change to the existing system, it has not been exposed to the appropriate “management of change” or engineering analysis.
- Preparation for the next run – At the conclusion of a TA, the next operating run will commence. In order to comply with the “business model” the operating unit

must be able to operate for the expected number of years. The unit must be able to produce a product meeting the specific specifications and requirements. The plant must be able to produce the desired product at the required production rate, with the required reliability and availability and at the required efficiency. All activities needed to ensure that the facilities operate as described must be accomplished during the TA.

- Resource utilization – Clearly, TAs are heavy consumers of all kinds of plant resources. During the period of time that a TA is being prepared and executed, it is likely that other activities within the plant where the TA is being done and within the company where it is being done will deal with a scarcity of resources. Since the TA is consuming shared resources with other activities operating within tight limits, it is critical that the TA be conducted in a manner that effectively uses all the assigned resources. Wasting TA resources results in needed work in other parts of the plant or organization being ignored.
- Interference with other organizational objectives – During any activity that shares the stage with an on-going TA, each and every gathering must deal with an “elephant in the room”. That “elephant” is the presence of the TA and the effect it has on other activities. It is incumbent on individuals who manage TAs to do everything in their power to avoid adverse impact on other simultaneous activities.

As with most things in life, it is impossible to meet the ultimate objectives by tackling the issues head-on. For example, one does not improve the OSHA recordable rate by simply eliminating the specific events that cause OSHA recordable incidents. It is necessary to generally address all unsafe actions and unsafe conditions to improve safety performance. Likewise, it is necessary to address the general circumstances that set the stage for overall TA performance in order to achieve the goals described above.

Unlike most on-going activities and other forms of large projects, TAs are activities that once started, tend to go seven days a week and twenty-four hours per day until complete. As a result, other than newly discovered work, all known work must be thoroughly planned and scheduled in advance. There is no time during a TA to plan or schedule work that was or could have been known in advance. Because of this, a useful measure for the level of preparation for a TA is the amount of planning and scheduling that has been completed. If the individual plans for the tasks that make up critical path and near critical path jobs have been optimized and if the overall schedule has been optimized, then it is likely there was enough planning in preparation for the TA. Let's spend some time focusing on just what that the last few sentences really mean.

In the sequence of events leading up to a TA, the following steps are typically followed:

1. The jobs making up the scope of work are assembled. These jobs will fulfill all the requirements for the upcoming run as described in the objectives above.
2. Once all the jobs have been identified, they will go through some form of approval process.
3. Once approved, a planner will visit the work-site for each and every job and prepare a scope of requirements, like scaffoldings, lighting, and other special needs.
4. Once the scoping is complete, the planner will prepare a planning package that includes all the steps necessary to complete each job as well as a list of all tools and materials as well as all of the staging requirements.
5. When all the jobs are completely planned, they will be inserted into a schedule that takes into account the sequential nature of some of the jobs as well as the resource limitations and other schedule restraints.
6. When the complete schedule is assembled (assuming it is assembled into some form of scheduling program like MS Project or Primavera) the first schedule will be calculated. This first schedule calculation provides the first estimate of the duration of the TA.

In some cases, this is the end of the planning and scheduling process. If so, this example would not meet the requirement for planning or scheduling optimization. In the situation where the individual plans and the overall schedule have been optimized, the planning/scheduling process would continue with the following steps:

7. The scheduler would look at assumptions that have been made concerning working shifts (for example 2-tens or 3-eights) and working days (for example six day weeks) to determine the impact of working critical path jobs for more shifts, longer shifts or more days. This approach will typically shorten the duration of the TA by some amount.
8. The scheduler will then tell the planner which jobs are making up the critical path or near-critical path jobs. The planner will then investigate other approaches at completing the work during the TA in less time. Frequently this will entail more expensive strategies for completing some small portion of the TA but it will reduce the duration and the overall cost of the TA as a whole. As an example, rather than rebuilding some components during the TA, it might save time to purchase spare components that can be renewed after the TA is complete. The renewed components can then simply be installed during the TA.
9. Once the selected job plans have been optimized, the new strategies will be input into the schedule and the schedule re-calculated. In some cases, it might be possible to further refine the schedule by adding resources or additional supervision to specific jobs to ensure no time is being lost.

By the conclusion of these additional optimization steps, the planners and schedulers can be reasonably confident that the overall TA duration will be optimized. The process of reviewing and optimizing the schedule typically results in added focus and accuracy for other TA jobs and for the overall TA supervision and management. As a result, the process of TA optimization typically results in a much better TA in general.

Key Elements of the TA Process:

As the title of this section highlights, it is most important to recognize that the system for planning and executing TAs is, in fact, a business or work management process. Unlike random activities that individuals just go and do without a great deal of structure and discipline, business processes and work management processes are highly structured and there are assurances that the events accomplished using those processes are highly disciplined.

To further emphasize this point, let's consider a company or a large plant that has a significant number of TAs in any year. When TAs are accomplished using a structured work management process, all TAs are accomplished in the same manner. As a result, similar results can be expected from all the TAs accomplished using the same process for development and execution. If a structured process is used to prepare and execute all TAs, it would make little difference who managed the TA or where it is accomplished; the results could be expected to be similar. The TA would be safe, environmentally clean, on-schedule, on-budget and able to produce the expected product.

Unlike many business or work management processes that occur all within the span of a few minutes or hours, the process used to plan and execute a TA occurs over eighteen months to two years for large TAs. The decision how far in advance the TA preparations would begin depends on several factors:

- The size and complexity of the TA
- The amount of lead-time needed to purchase or fabricate parts
- The need to integrate a TA with a major project that will modify the asset involved in the TA
- The experience level of the individual(s) assigned to manage the TA
- The number of times the unit in question has experienced TAs
- The need to arrange for particularly large or skilled workforce

For relatively small and simple TAs that are copies of ones that have occurred numerous times in the past and are being managed by experienced TA Managers, it might be possible to begin the TA process only with sufficient advanced notice to order long lead-time materials. On the other hand, other particularly challenging situations

might demand that the initial steps of the TA process begin two years prior to the anticipated start-date for the outage. One point to keep in mind is that if it is discovered that the challenges are not as great as initially anticipated, it is always possible to slow things down. On the other hand, when it is discovered that the challenges are greater than expected, speeding-up the preparation process can become very expensive.

The following are the generic steps needed to perform a TA along with brief descriptions. While the starting points for each of the steps are typically sequential, frequently the steps overlap. In other words, one step does not end before the next step begins. Occasionally, three or four or more of the steps occurring simultaneously are being handled by different members of the TA Team.

It should be noted that it is necessary that the timing of the start of each of the steps be identified in a TA schedule. (I have not attempted to describe the steps of the TA process on a timed schedule in this short course because, obviously, the timing of the steps for an outage beginning two years in advance would be different than the one that begins only nine-months in advance.)

The elements of the TA process include the following:

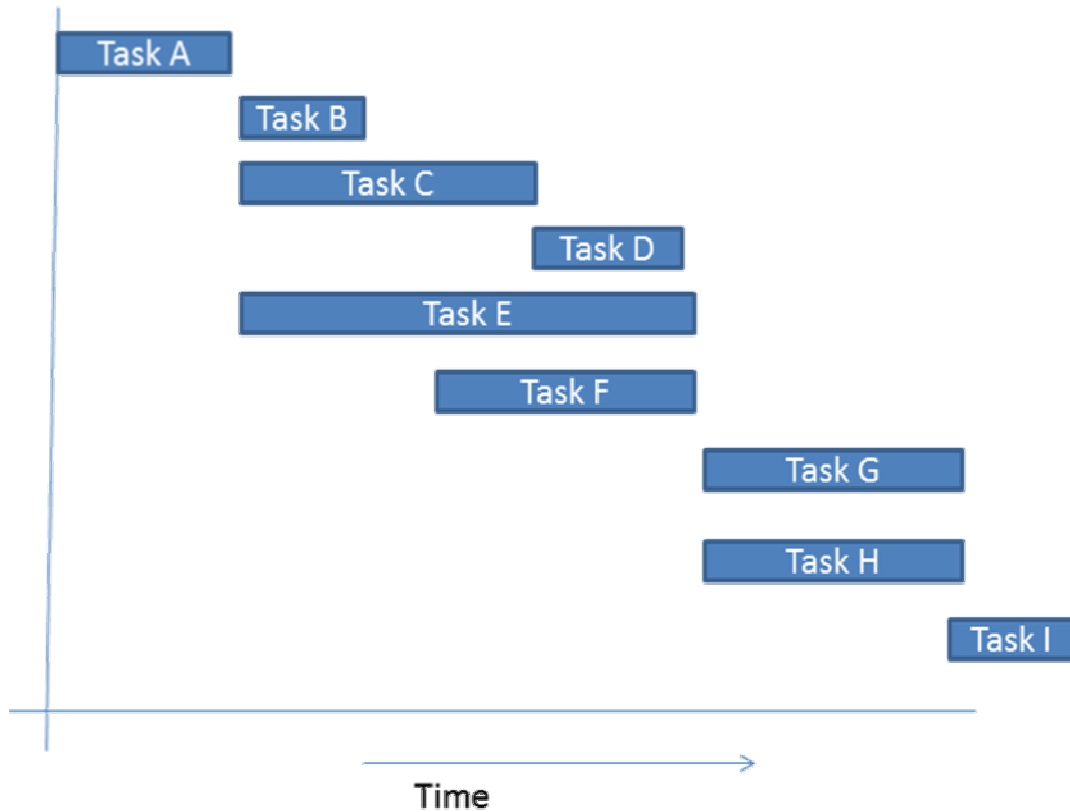
1. Identify TA Manager – The first step of the TA process is to identify the individual who will act as the TA Manager. This person should have all the traits of a Project Manager who is typically assigned to handle projects that are executed with the same intensity as will be the TA in question. For instance, if the TA will have a workforce of 100 people working on days only, the TA Manager can be the equivalent of a Project Manager for fairly small projects. On the other hand, if the TA will ultimately employ 3,500 people per day and be conducted on a round-the-clock schedule, seven days per week, the TA Manager should have the same skills as a Project Manager who is used to handling some of the largest and most complicated projects.
2. Assemble TA Team – Assignment of the TA Team is one of the most “ticklish” issues associated with the successful accomplishment of a TA. While the preparations for many TAs begin well in advance, the intensity of TA preparations do not justify the full-time involvement for many of the team members. Steps like the identification of all required jobs needs to be completed well in advance so job planning, organizing, scheduling and long-lead material ordering can be completed in a timely manner. Frequently, part-time TA-Team members have a difficult time prioritizing the importance of TA activities that are well beyond the immediate time horizon when compared to their day-to-day tasks that are urgently demanding immediate attention.

In those cases, it is important to identify the “right” individuals to be TA Team members and to clarify their accountabilities at the time of their assignments. They need to accomplish the TA work demands “on-schedule” as assigned or the overall TA planning will be delayed and TA preparation will ultimately be squeezed into an inefficient and ineffective timeframe.

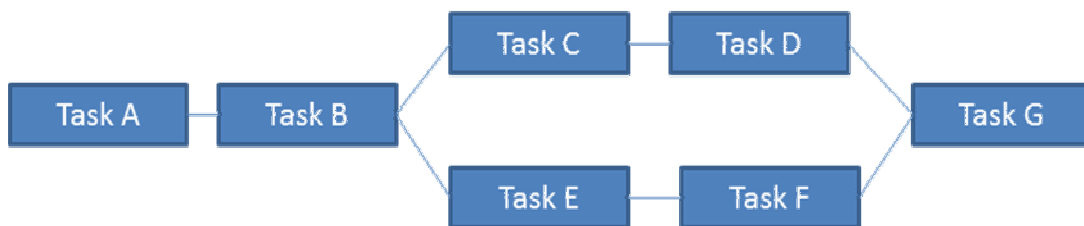
The following is an example of the members of a TA Management Team:

- TA Manager
 - Operations Coordinator
 - Process Coordinator
 - Safety Coordinator
 - Environmental Coordinator
 - Scheduler
 - Planner(s)
 - Contractor Coordinator
 - Procurement Coordinator
 - Material Expeditor
3. Adapt TA Calendar and Control Document – There are two tools that are helpful in organizing TA preparations and making them clear to all members of the TA Team. The first is the TA schedule and the second is the TA Control Document.

A TA schedule is a device that shows the tasks that must be completed and the times at which they need to be completed. The simplest form of a schedule is a Gantt chart that shows each of the tasks as bars. For clarity, the bars are frequently arranged sequentially with the earliest activity at the top and sequentially later activities below. The following is an example of a Gantt chart:



Another form of a schedule is the block diagram that is laid out in a logical fashion. This form of schedule is helpful in identifying the Critical Path or the longest sequence of events for any project. The block diagram adds the ability to easily see predecessors (tasks that must be completed before the next task can begin) and successors (tasks that can be started only after the current task is complete). The disadvantage is the size or length of the boxes in no way portrays the relative length of a task as do the bars on a Gantt chart. The following is an example of a critical path block diagram.



A TA Control Document is another device used for managing the schedule and completion of tasks. Unlike either of the schedules described above, a control

document can be assembled in a simple spreadsheet format. The control document provides a list of the following:

- Task Name
- Task Description
- Need Date
- Individual to whom the task is assigned
- Current Status
- Actual completion date

The control document is a tool that can be used at regular meetings as a basis for reviewing the status of current activities. Since it clearly identifies the individual who is responsible for each task and the need date, it leaves little room for discussion. It clearly identifies situations where individuals are failing to meet their responsibilities. As new tasks are identified, they are simply added to the list along with the need date and the assigned individual.

4. Develop TA Premises - Another tool that is useful in preparing and executing a TA is the TA Premises. The TA Premises are a set of bullet points that describe what and how the TA work will be accomplished. Rather than spending a great amount of time in an abstract discussion of TA premises, I will simply provide an example list of TA Premises. Once assembled, the list of TA Premises becomes the “rules” by which the TA is organized and accomplished. If a situation arises that will cause the TA Manager or TA Team to take some step or perform some act that is inconsistent with the TA Premises, that situation should be escalated to Plant Senior Managers for resolution. The following is a typical example of a set of TA Premises for a large TA of an operating unit in a refinery:

- There will be no lost time accidents.
- The OSHA recordable rate will be less than 1.0.
- The TA will be completed within the allowed budget.
- If there is no added work, the entire Work Addendum allowance will be returned.
- If there is no unforeseen foul weather or delays, the entire Contingency allowance will be returned.
- The TA, including time allowed for shutting the unit down and starting it back up will be completed within the allowed scheduled.
- No work that can be safely and efficiently completed outside the TA duration will be done during the TA.

- The unit will be maintained in a manner during the TA that will achieve the longest run possible. The TA documentation will include an explanation specifically why a longer run after the TA is not possible. Valid reasons include effective catalyst life and regulatory requirements for internal inspections; work needed to achieve a longer run will not be cost effective or time effective.
- Lacking the premise to achieve the longest possible run, there should be a premise identifying the exact targeted run-length after the TA. For instance, the unit will be capable of operating 60 uninterrupted months before the next TA.
- TA progress will be discussed in a daily meeting by individuals directly involved in the TA. Others will be updated daily via an e-mail report.
- The TA will be critiqued within two months after the unit has returned to operation. All improvement opportunities will be documented and addressed before the next scheduled TA.

While the above list is fairly comprehensive, it is not intended to be either complete or specific for each TA. It will be necessary for each TA to tailor the premises to meet their needs. It is important to create a comprehensive and accurate set of premises early in the preparatory phases so that the premises can be used as a basis for all decisions made during later phases of the TA. For instance, if the premise to disallow work on spared equipment that can be worked on the run is made, it will be necessary to apply that premise when assembling the worklist and when approving work added during the TA.

5. Assemble TA Worklist – While the TA worklist is very similar to worklists for earlier TAs, simply copying an earlier worklist is a mistake. The worklist for each TA must be created to meet the current needs of the unit being maintained and to achieve the particulars of the specific run following the TA. For instance, it is frequently possible to increase the run-length between outages by taking steps that will improve the run-limiters. When this is done, it is important to see that all other components are also prepared for the longer run. Simple items like the inspection intervals based on the half-life of pressure retaining equipment must be checked to see that the half-life does not occur before the end of the revised run-length. If there are cases where the half life expires early, it might be necessary to build up the corrosion allowance in particularly thin areas to extend the half-life duration.

Also, there might be instances where work done on past TAs can be eliminated from this TA. It is important to keep in mind that no credit is given for performing unnecessary work.

6. Close TA Worklist – In preparing a complete and accurate worklist, it is important to gather all the necessary work before planning and scheduling begins. If all the work is not included during the period of time set aside for planning and scheduling, that process will be made less effective and much of the work will need to be repeated later. One way to ensure that all the individuals responsible for identifying work do their best during the work identification period is to formally close the worklist at the end of that period. After the worklist is closed, adding work to the TA will require a much more cumbersome and painful process. Typically rather than simply adding the proposed work to a list as is possible during the normal work identification period, individuals who are delinquent in providing their inputs must take their items to an approval committee consisting of plant senior managers. This kind of exposure is viewed as being the kind of thing most people would like to avoid.

Later in the TA Process, work can be added to the worklist using the Work Add process. Again this approach is more difficult because it consumes money set aside for true work adds and the individual who identifies the work will need to explain why it was impossible to identify the proposed work at the proper time during the TA Process.

7. Initiate Cost Tracking/Forecasting System – It is fairly early on in the TA Process that a sizeable amount of resources begin to be consumed working on TA preparation. As a result, it is important to begin using a Cost Tracking system to capture those costs. While the earliest forms of the TA financial system are purely a Cost Tracking system, ultimately the system needs to transform into a Cost Tracking and Cost Forecasting system.

The TA budget is not a forecasting system. The budget is simply a method for setting aside money so the corporate cash flow takes the large expenditure for the TA into account. The TA Cost Forecast is the TA Managers best estimate of what the TA will cost at the end when all charges for the TA, as it was performed, have been received.

Early on in the TA process, when there is no evidence that the TA will cost any more or less than the budget, the TA budget provides the best forecast available. Once things start happening, work is added, work delays add unexpected costs, deterioration is found to be greater than expected or the workforce is found to be less productive than expected. Therefore, it is necessary to update the cost forecast with these changes.

The cost forecast is made up of three elements: spent, committed and remaining to be spent. The spent amount can be tallied directly from invoices. The committed has yet to be invoiced but can be calculated based on actual crew size versus expected crew size, actual progress versus expected progress, actual material costs versus expected material costs and so on. The remaining to be spent can be calculated based on the progress yet to be made and the associated costs as adjusted by the historical trends during the TA. For example, if half the TA remains to be completed but you have already spent and committed 75% of your budget, you can expect the completed TA to cost 150% of the original budgeted amount. That would be the amount the TA Manager should report as the TA Cost Forecast.

8. Conduct Work-List Review – Once all the lists of proposed or recommended TA work have been received, they need to be integrated into a comprehensive “proposed worklist”. Once the worklist is complete, a review process should begin. This process will include all individuals who are stakeholders and decision makers for the unit being maintained. Depending on the size of the unit and the size of the worklist, the review process can take a number of days to complete.

During the review, each item on the proposed worklist should be reviewed. The basic test is if each item is needed or not. A more in-depth test answers the question if each item meets the requirements established by TA premises. Those that do not meet the TA Premises or are unnecessary to achieve those premises will be eliminated from the worklist.

Items that remain on the worklist at the conclusion of the TA review will be completed during the TA. Work not on the worklist at the conclusion of the TA Review will need to pass through the work add process if it is to be completed during the TA.

9. Order Long Lead-Time Materials – As soon as work is approved for inclusion in the TA and the associated budget authorities have been created, long lead-time materials should be ordered. Typically some amount of engineering or other analysis must be done to identify and specify the long lead-time materials. That work should be done and the orders made as soon as possible so the delivery schedule does not delay the TA and the overtime cost needed to produce the material by the TA are minimized.

10. Conduct Detailed Planning - A useful way to look at the level of planning needed for each task performed during the TA is this: Workers performing each job

should be able to gather all the required tools, materials, instructions, permits, drawings or other items to perform the work before traveling to the work site. There should be no reason to leave the work site until the task is complete. If an individual has to make several trips to the worksite, the job was inadequately planned.

In order to meet the requirements identified above, it is helpful to create a Work Pack for each TA job that contains the following elements;

- A complete list of the steps needed to perform the job
- A complete list of the tools needed to perform the job
- A complete list of the materials needed to perform the job
- Drawings describing the finished product
- Safe work permits, confined entry permits and hot work permits
- Scaffolding, lighting and other job staging requirements
- Lift plans
- Crew size and special skills
- Welding procedures and qualifications
- Ventilation requirements
- Personal protective equipment
- Anything else needed to complete the job without interruption

11. Develop/Release Bid Packages – Once the planning is complete, it will be possible to release bid packages for some, if not all, of the discrete jobs. Jobs like column re-trays, refractory installation, re-tubing heaters and exchangers, compressor overhauls and a variety of other jobs can be adequately described in distinct job packages that cannot be sent out for bids. Rather than depending on the critical path schedule, these large jobs are typically combined with other preparatory or concluding tasks to create the critical path sequence of events.

12. Integrate Capital Projects - Most major TAs contain some number of capital projects. Often a capital project used to provide a major revision to an operating unit will form the center piece and the critical path sequence of events for a turnaround. Occasionally, TAs are used as opportunities to make tie-ins that will serve as connections to new operating equipment. In this case, most of the capital construction can be done while the unit is still in operation. In other situations, major equipment items are to be modified by the capital project and, in those cases; significant portions of the capital project must be completed with the unit not operating.

In the latter situation, the capital project is typically operated on a TA schedule. It is critical that all work completed during a TA, including all capital work, be scheduled using the same protocols as TA work. When capital work is completed during a TA, the capital work must be fully integrated with TA work. It must be planned using the same kinds or work packs and scheduled using the same scheduling techniques and on the same schedule (frequently seven days per week and twelve hours per day).

13. Develop SD and SU Plans – The transition of an operating unit from being on-line to being shut down and ready for maintenance or capital work is an intensive period. During this time, the feed, intermediate products and products must be removed from the operating unit and properly stored. The unit must be decontaminated so it can be opened and entered. The unit must also be blinded or otherwise isolated so it is safe for work.

The opposite is true on the other end of the TA. Equipment must be cleaned and flushed to ensure that all debris has been removed. New or revised pressure retaining systems must be pressure tested. Blinds must be removed. Each system must be re-inventoried. The systems must be warmed and pressurized. Finally, the systems must be placed on circulation and when products are on-spec, the production and fresh feed can begin.

In order to have a comprehensive schedule, it is necessary to include the activities included in both the shutdown and the start-up. In addition, it is necessary to closely integrate the shutdown activities with start of TA work and the completion of TA work with start-up activities. Frequently, the shutdown activities will open a portion of the plant to begin TA work but not the entire plant. Also, as TA work is completed, it might be possible to begin start-up activities on a portion of the plant but not the entire plant. In order to absolutely minimize the TA duration and to minimize the TA crew size for the duration the TA crew is held on-site, it is important to take advantage of the scheduling opportunities that work integration can provide.

In analyzing shutdown and start-up plans it is important to ensure that the plans are up-to-date and that they are appropriate for the specific work that was completed. Occasionally new products are developed that facilitate faster cleaning of contaminated equipment. Also occasionally, the work being done during a TA is sufficiently different from past TAs that the shutdown or start-up procedures need to be modified to address the specific needs of the TA.

14. Develop Final Cost Estimate – The final cost estimate can be developed after the detailed plans for all work have been completed but before the final schedule is completed. The sum of all individual workforce estimates identifies the overall man-hours. The critical path duration including shutdown and start-up interval identifies the TA duration. Total man-hours divided by critical path duration determines the daily workforce size. The portion of critical path and near-critical path work determines the amount of the crew that must be worked on second (and possibly third) shifts. The portion of the crew on second and third shifts will determine the percentage of man-hours that will be paid on a premium time basis.

Depending on the type of plant, the type of equipment that is being replaced and the metallurgy of the equipment, there are short-cuts for estimating the labor to material ratio. For plants made principally of carbon steel components and situations where no single costly component is being replaced, a 50/50 ratio of material to labor is typical. In that case, it is possible to multiply the cost of materials by one to get an estimate of material costs that will serve until a detailed Bill of Materials is complete and specific material costs can be estimated. In that case, the total cost of the TA is estimated at two times the labor cost.

When the plant is constructed of more costly alloys, the ratio of materials to labor may be 60/40. In that case, the cost of materials is 1.5 times the labor cost and the total cost of the TA is 2.5 times the labor cost.

When there is one or more high cost components being replaced (Like complete compressors or fractionating columns) it is best to separate the cost of materials and labor for those components from the general TA costs because their material to labor ratio is inconsistent with the rest of the TA.

While these shortcuts are useful in developing a TA cost estimate, it is always best to develop detailed estimates based on actual costs as soon as possible. The accurate detailed cost information will be used later during the TA to help reconcile estimated costs as compared to actual spending. For instance, if materials are costing more than expected during the TA, it will be important to go back and find out why current costs are inconsistent with the bids collected prior to the outage.

15. Create Comprehensive Schedule - Once all job plans have been completed and the sequence of work steps is clear, it is possible to assemble the detailed schedule. Depending on the size and complexity of the TA, it is often best to use

a TA scheduling program to assemble all work and calculate the schedule. Programs like Microsoft Project can be used for small TAs and Primavera can be used for large TAs. These programs are similar in their capabilities and differ primarily in their capacity (number of tasks).

Critical Path scheduling for a TA is a subject by itself. So only a few important points concerning TA scheduling will be covered here.

- The computer schedule should not duplicate the information contained in the Work Packs. Rather it should serve as a “call-file” telling when it is time to pull up the next work pack and get a crew of craftsmen working on it.
- There is always a balance between too much detail and too little. Using the planning Work Packs as the primary repository of information will help avoid having too much information.
- To avoid having too little information, it is helpful to create some standard practices describing when new steps should be added:
 - A new step should be added when the craft performing the work is changed.
 - A new step should be added when there is a “hold” or inspection point.
 - A new step should be added when a discrete element of work is complete and another is starting.
 - It is important to provide steps at measurable milestones so it is possible to gage progress on long jobs. For instance, if a large gunnite refractory job requires six days to complete, there should be a step at the conclusion of each 20% or the work during which progress can be measured against the time, material and labor that has been consumed. These milestones will be useful on making sure the job does not run behind schedule or ahead on costs. While the physical work may not stop at the milestones, the status can be measured at those points.
- While few people choose to use the schedule as a basis for managing the budget, the schedule should be adequately accurate to do so. It is critical that the schedule can accurately portray how closely the P/A (ratio of planned work to actual work) is being achieved. The P or planned amount in the schedule should also be the budgeted amount less contingency and addendum. If that is the case then a P/A of greater than one will reliably report that work is being completed with fewer resources than planned and the TA is operating under budget. If P/A is less than one, then the

actual resources being spent are greater than the amount planned and budgeted. Therefore, the TA is running over budget.

16. Assemble Work Packages – As a continuation of the planning step described above, there is a step that is largely clerical but also aimed at ensuring all the workplace needs are met. In performing this step, it is important to consider how the work management process will be accomplished in the actual workplace. The following provides an example. The example being provided may not match your work management process, but it should help you think about the issue being described.

Each evening of the TA, the scheduler obtains marked up schedule sheets from each of the work planners or first line supervisors showing the progress that had been made earlier that day. The scheduler puts all the information into the scheduling software and re-runs the schedule to determine which jobs should be scheduled for the next day. Once the scheduling software has identified tomorrow's jobs, the scheduler goes to the Work Pack files and removes one set of the work packs. The file contains several complete sets of work packs, depending on how the field workforce is organized. If one person manages all aspects of the field work, there need be only two complete sets of work packs: one to use in the field and one to keep on file in case the other is lost or damaged. If the work place is organized in such a manner that there are several individuals supervising the field work (say by craft line), there will need to be more than two sets of work packs. There are always at least two sets of work packs: one to leave on file and one to be used in the field.

In some cases, the work packs do not need to be complete copies. In the case where one work pack is for the scaffold builders, their work pack need only contain information important to their work.

17. Conduct Management Review – Once the scope, schedule and TA costs are known, it is important to assemble a comprehensive presentation that completely describes the anticipated TA. This presentation should be given to plant (and possibly corporate) senior managers so they will thoroughly understand the planned TA. All members of the TA team should attend the Management Review so they can comment when appropriate.

It is not uncommon for differences in understanding to come to light at these meetings. If differences are identified, they need to be resolved quickly.

18. Optimize Schedule and Job Plans – A key measure of TA preparedness is the opportunity to optimize the TA schedule and to improve work plans for critical path and near-critical path jobs. When the preliminary plan is complete, it is not uncommon to have the duration set by two or three work paths that are significantly longer than all other work paths.

In these cases, there are a variety of steps that can be taken to reduce the overall TA duration:

- Increase the size of the workforce working on the critical path jobs.
- Increase the number of hours or shifts being worked on critical path jobs.
- Modify the approach being used to complete the critical path job(s) by moving work outside of the TA. Use prefabricated components.
- Identify better efficient tooling (like robotics, high pressure water cutting or explosive removal techniques).

Whatever steps are taken to improve the TA duration, it is important to consider the effectiveness of reducing the duration of more than just a few job paths. For example, if the TA has ten jobs with durations that are nearly the same, to improve the overall TA duration, it would be necessary to invest the resources needed to improve all ten jobs. In addition, it would be necessary to spend the resources to tightly manage ten competing jobs.

Now think, how likely it is that you will be successful with this strategy. It takes only one job path to collapse; resulting in the TA duration returning to the pre-optimization duration. In that case, all the money and resources that were spent to reduce the TA duration would be wasted. It is best to focus on reducing the duration of just a few job paths.

19. Release Purchase Orders and Rentals – Occasionally you will find that your TA is competing for large cranes or other specialized equipment during the time that has been selected for the TA. The same may be true of specialized work crews.

This point emphasizes the importance of identifying special needs as early as possible, releasing bid packages and getting the key resources under contract.

20. Assemble Execution Team – The TA Management Team will work together throughout the preparatory period. Many members of the TA Management Team will become members of the TA Execution team, but there will also be other members. In addition to the members of the TA Management Team, individuals filling the following roles will become members of the TA Execution Team:

- TA Supervisor
- First Line Supervisor(s)
- Contractor Coordinator(s)
- Craft Foremen
- Heavy Equipment Supervisor
- Equipment Inspector(s)
- Safety Inspector(s)
- Material Planners
- Timekeepers
- Etc.

The number and kind of field personnel added to the execution team will depend on the size and complexity of the TA.

21. Complete Field Staging – It is critical that work be able to begin at full scale on the very first day the unit is down and cleared for work. It is important that all job staging be completed prior to the date feed is taken out of the unit. The following are examples of the kinds of preparations that should be completed prior to the TA:

- All materials purchased specifically for the TA should be staged in a convenient lay-down yard that is organized in a manner that allows the items to be easily accessible and quickly found.
- Stationary lifting equipment should be cribbed and rigged for special lifts that will occur during the TA.
- Office trailers, tool trailers, portable toilets, and other facilities should be installed in convenient locations.
- All lighting for night work should be installed and powered.
- All possible scaffolding should be installed.

22. Initiate Work Add System – Before the beginning of the TA, the Work-Add system that will be used during the TA should be initiated. Rather than waiting for the storm of work that arrives during the first few days of the TA to smooth out the Work Add review and approval process, it should be in place and functioning before the beginning of the TA.

23. Begin Tracking Schedule and Costs – Much like the Work Add system, it is best if the process for distributing work from the schedule, updating status and integrating new work into the schedule is in-place and functioning smoothly before the actual TA begins.

24. Begin Tracking Key Measures – A third area where it is useful to have started and smoothed operation prior to the start of the TA is the system of Key Performance Measures that will be used to manage the TA. Two critical examples are cost and progress. Each of those areas rely on a system for collecting information, placing the information in computerized systems, running some form of calculations, reviewing the results, comparing results to expectations, then integrating the data into some kind of report. It is better if the steps in this process have been tried and proven prior to the start of the outage. If not in-place and functioning prior to the TA, it is likely that the systems will never be implemented as expected. Key personnel will need to focus on completing work; not setting up TA systems.
25. Start TA – A key milestone is the actual start of the TA. This is the day that activities transition from preparation to execution.
26. Conduct TA Following Schedule and Detailed Plans – While it might seem apparent, the next critical step is to complete the TA using the schedule and the plans that were prepared. There are many situations where lots of planning and scheduling is completed prior to the TA, but all the plans are ignored once the TA begins. All too often, the first time there is a problem that is not addressed by the planning, people throw up their hands and start shooting from the hip. This is a mistake. In any TA, there are issues than must be managed by exception. Despite that, the vast majority of the TA can be managed by objectives.
27. Complete TA – Another key milestone is the completion of the TA work and start-up of the unit.
28. Close all Accounts – Within a relatively short period of time, it is important to close all TA accounts. This is an important step so unrelated costs do not continue to be charged to the TA. For accounts to be closed in a short time, special steps must be taken:
- All rentals must be returned as soon as the jobs, on which they are used, are completed.
 - Trailers and other temporary facilities must be disconnected and dragged off-site.
 - Contractors and suppliers must be given “drop-dead” dates for final billing.
 - Excess materials must be gathered and returned.

- Mischarges to TA accounts must be reconciled and reversed to their proper accounts.
- All crews and staffing must be reduced and laid off as quickly as possible.

29. Critique TA and Update TA Files – One final step for every TA is a timely critique and file update. People's memories of the problems they experienced during a TA tend to soften as time passes. The resources needed to assemble information are soon assigned to other activities and the past TA is only a memory. If the TA is not quickly critiqued and files are not updated, the next TA will suffer from the same shortcomings as past TAs.

As difficult as it might seem, it is critical that a candid critique be completed and all critical information be filed in a manner it can be used for the next TA.

Conclusion

While many people tend to look at TAs as being very similar to projects, there are critical differences. While much of the work planning for a project can be done on a day-to-day basis, all planning and scheduling for a TA must be done in advance. Only newly discovered work should be planned and scheduled during the TA.

Another difference is the rate at which work is being accomplished. Most projects are worked on a five-day week and eight hours per day. Increasingly TAs are worked on seven-day weeks and round-the-clock schedules.

For the most part, TA work is maintenance and the objective is to “put it back the way it was” whereas projects typically involve the creation of new systems.

Despite all the differences from projects, there are some critical similarities between TAs and projects. Most significant is that the success of both TAs and Projects depend on organizing and managing three things:

- Scope
- Schedule
- Budget

These three factors tend to be the measures on which both Project Managers and TA Managers are judged. Beyond these three factors that are measured in terms of “shades of gray”, there are two factors that are “black or white” indicators of success. They are:

- Safety Performance
- Environmental Performance

No TA will be considered a success that is viewed as unsafe or environmentally unsound.