

# preprocessinc

## *Chemical Engineering for Entrepreneurs*

### **Testing and Balancing, Commissioning, and Operationalizing Systems**

After construction completion, the focus in a project turns to the commissioning effort. There are many different experiences and definitions for the commissioning efforts and many times there is a significant overlap between the commissioning effort and the construction efforts. Unless a design is a repeat of a tried and true technology application, there are usually changes that need to occur to bring the system up to performance expectations. In a re-application of a previous design, these are usually site specific and feedstock specific minor changes. If this is a first of a kind system at this scale, the need for flexibility and change management during the commissioning effort can be significant.

Commissioning has four major parts. The first is the testing and Balancing of the system to get it loaded and at process conditions. The second parallel effort is the training of the operations view during this time so they can take the hand off and turn over from the commissioning team once the system has met its performance criteria. The third element is the commissioning of the system using designed extended experimental runs to test each performance aspect of the design to its design limits. The fourth is the operationalization of the system whereas the trained team takes over from the TAB and commissioning team so that they can demonstrate the ability to run and maintain the system under normal operating conditions. This also is the time when all emergency response and mitigation systems are examined, drilled and analyzed for fit readiness for long term reliable and safe operation.

### **Testing and Balancing “TAB Team” Structure, Roles and Responsibilities**

The Testing and Balancing (TAB), Start Up and Commissioning Team, or simply the “TAB Team” will focus to remain nimble and responsive to the complex interdependent needs of the units during the testing, balancing, start up, commissioning and operationalization effort. The sequenced start up will be executed by the TAB Team. The effort will use series of shakedown runs that will then evolve into designed experiments to develop the needed correlations and performance metric targets that enable the long term reliability in the performance overall system. The team will use Obvious At A Glance (OAAG) information dashboards to keep communications simple and straightforward. The ultimate operations philosophy is to use a “lights out” type of control room and allow most of the routine operations to be automated by locking the various algorithms and correlations in the process control system to keep a tight steady state operation enabling repeatable, reproducible reliability in product and operations.

The TAB Team leader who will function as the traditional start up chief operating engineer. The team leader is responsible to drive the TAB Team operations and performance metrics with the

ultimate goal of meeting the overall site wide system proof run metric targets. There is one accountable team leader. However, leadership is rotational. Each team member is a partner and member of the team who is individually responsible for defining the intended product and process metric target requirements for each system that they champion.

Leadership and coordination authority derives directly from and reporting to the Project or parent organization Executive Leadership Team (ELT) to guide, direct and coordinate all process system and process equipment engineering, design and installation and will lead all Testing and Balancing (TAB), Start Up and Commissioning Teams to integrate the overall system, testing, balancing, start up, commissioning and problem solving, to insure that the various responsible engineering firms, equipment vendors, and construction contractors deliver a safe, functional, maintainable and operable system.

TAB teams are the first step in the commissioning effort and they provide process development, engineering development and construction integration coordination to insure that all technology developed and systems installed are defined and evaluated by performance metrics that use accepted statistically valid measurement methods and the responsible engineering and technology firms deliver technology solutions that meet the agreed performance metrics.

The team must have the authority to assign, direct, coordinate and drive to closure binding action item deliverables onto the responsible engineering firms, technology providers, vendors and construction contractors.

At some point the TAB team and the operations team have to agree on the tactical responsibility of operating the equipment during this blended period of operation. The team must have the unencumbered authority to test, balance, start up, commission, operationalize and deliver the required proof tests required to demonstrate that the specific engineering, equipment vendors, and construction contractors have delivered a safe, reliable, maintainable and functional system meeting the design basis and ELT directives that have been defined or will be defined during the life of the project.

The team leads the multiple party co-mingled TAB, Start Up and Commissioning Teams for each of the process system builds as defined by the continuing activities of the project and other integrated directives of the ELT. The TAB teams may be comprised of multiple organizations including but not limited to the design engineering firms, equipment and system vendors, the construction contractors, members and components of operations, technology and the crew from the collective bargaining agreement that has been established and has been in force at the site. The activities and the required operations of the TAB Teams will be directly led and will directly report to the TAB Team leader, who will act as the traditional chief start up operating engineer with the authority and under the direction of the ELT. Under direction and coordination of the TAB teams, engineers and collective bargaining agreement operators will physically operate and control the operations of the equipment, execute the day to day tasks and insure the safe operation and controlled movement of materials site wide through the system being responsible to act consistent with the tenets, practices, means and methods

defined for the site. The TAB Team Leadership will relinquish control of the operational aspects of the TAB, Start Up and Commissioning efforts once the operators are trained and qualified and the system designed experiments and performance metrics for the site wide integrated system have been met for the individual systems so that operations can then reliably operate and maintain the system.

The team is responsible for the site wide overall integration of the site wide interdependent process systems insuring that the overall mass balance, energy balance, utilities consumables usage, product specification and production capacity meets all defined and developed performance metrics.

The team troubleshoots and resolve all system performance issues that arise assigning the engineers responsible for the system to implement and execute changes to the identified underperforming systems. The team assigns deliverables, and actions items to the responsible engineering and construction firms to complete design and installation tasks to mitigate the systems and equipment that are identified as having errors, omissions, or have proven to underperform or functionally not work as intended. The team contributes and drives the solution to the process system issues, but will not inherit or transfer any responsibility from the responsible engineering or construction firm having to deliver the functional performance of the design or construction scope for which those engineering and construction firms were contracted to deliver.

### **Yellow Line Turn Over (YLTO) and Pre-Start Up Safety Reviews (PSSRs)**

“Yellow Line Turn Over” (YLTO) is the hand over of the conforming record documents at mechanical completion that documents that all mechanical and electrical tasks are complete and signed off by the contractor and ready for hand over to the Pre-Start Up Safety Inspection team.

The YLTO Work Flow determines “Mechanical Completion” and establishes the earned value for the completion of the installation contract as per the Earned Value Plan.

1. All mechanical tests and all final inspections are completed.
2. The system is “walked” and “yellow lines” are marked on the P&ID and electrical single lines proving documenting that all installation and pre start up preparations are complete.
3. The Project Engineer turns over a copy of the yellow highlighted P&ID and electrical single line to Project QA.
  - a. Yellow lining means the device is safely installed, checked for complete installation as per drawings by the Engineer of Record, checked for alignment by a millwright, lubricated by a mechanic, has been bump tested by an electrician, is control checked and is safe and ready for operation.
4. Project QA performs an internal check to ensure there are no outstanding mechanical completion punch list items.

5. Project QA audits the Turn-Over Books to ensure QC Documentation is complete and secure.
  - a. A Turn Over book contains all documentation relative to the installation of the device. These include all inspection reports, installation certifications, equipment vendor support reports, operating and maintenance manuals, and mechanical completion checklists. The Turn Over Books are indexed by equipment tag number.
6. A Completion Certificate is submitted verifying the equipment shown on the P&ID is and electrical single lines is ready for service.
7. Project QA will stamp the Completion Certificate as accepted.
8. A Pre Start Up Safety Review (PSSR) is conducted by the TAB Team.
9. All PSSR Punchlist Items are resolved craft and trade support is supplied for completion of the PSSR Punchlist.
10. The individual system equipment is run for mechanical performance by the TAB Team.
11. The performance metrics are met.
12. The system is turned over to TAB.

### **The Attack Team:**

TAB efforts will identify design deficiencies in the system. In order to insure that these are addressed and resolved a small and focused “Attack Team” will be assigned the responsibility to design and implement the needed fixes as problems are identified. At “Construction Completion” (aka “Mechanical Completion”), yellow lined P&IDs, electrical single lines and electrical loop diagrams are delivered to the TAB Team. This is the point where the Construction Management (CM) Build Engineer has completed the “punch list” (aka the “but list”) and turns over responsibility for the system to the TAB Team. Any functional fixes now become the responsibility of the TAB “Problem Attack” Team. A sub system, device or pipeline is yellow lined when Program QC has in its possession: The alignment report for mill-wrighting all rotational equipment; the weld certs, hydro test, flange torques and leak test results for piping; the instruments are lit up and showing on the correct SCADA and HMI screens; motors are bumped and equipment is coupled up. Note that the drawings are marked with the yellow marker by the constructor who completed the system. It is the responsibility of the CM Build Engineer to compile and deliver the yellow lines to the TAB Team Lead (Marc P). Yellow lining the drawing also requires that the pipeline’s and equipment surface personal protection insulation be installed and all pipe lines in the system must be numbered.

The attack team efforts will ebb and flow and membership on the team will be augmented by the needed ad hoc members bringing the needed skill sets to solve the problems presented. The Attack Team Lead will be responsible to drive and complete the problem “hit list”. The Attack Team will use the CM contracting and change order methods, but the budget for the fix it hit list is from the overall start up budget, not from the project capital budget. The design leads will continue the production of the needed design and drafting documentation to deliver for the production engineering construction packages for change order execution. The Attack team will also be responsible for the initial maintenance for the equipment and systems. The equipment should not require the large amounts of routine maintenance in its initial

operations, but once TAB Operations runs are commenced, the routine procedures must be executed. The Attack Team will incorporate operations maintenance team members for training and heavy maintenance support, but the responsibility for maintenance of the equipment, until the overall site wide turn, over is with the TAB Team. The Attack Team will require a wide variety of craft skills and the team's numbers will fluctuate relative to the complexity of the problem solution. The crafts will include mechanical fitters, pipefitters, welders, assemblers, electricians and insulation specialists.

### **Specialists**

The system has unique equipment that requires specialized focus to insure properly installed equipment. The team requires specialists to support the fast paced nature of the team and to insure the timely training of the operators, safety program compliance, environmental program compliance and management of the procurement of specific additional equipment. One of the most important roles is the Overall Training Coordinator. The OTC has the responsibility to insure that the crew being trained to take ownership of the system in the operationalization phase has the skills and readiness to accept that responsibility. Another critical specialist role is the Procurement Lead. During TAB troubleshooting, timelines are compressed due to the sequential nature of the compounding downstream problems. The problem must be attacked, not just solved. Getting equipment to site to fix the problem in a fast and efficient manner is paramount to the effort. The role is critical to insure that any needed vendor interactions and additional needed equipment is delivered in a timely and cost effective manner. There are also many technical specialists who will ebb and flow in and out of the team structure. In some projects a particular technology may be applied in many unit operations where having that technical expert on the team will insure consistent success. An example might be a fiberglass re-enforced plastic (FRP) Specialist. The role is to insure world class FRP technology means and methods are applied in the field is critical to the long term reliability of the system.

### **Research and Development, Technology Development:**

The R&D technology group usually is the group that initiated many of the bench concepts that are now brought to scale in the commercial systems. The group should include the scientists who have developed the chemistry and bench scale prototypes of the equipment used to design the full scale system. This group continually supports the needed lab and bench scale work as the scaled up system is brought on line. The specialized functional operations that make up the building blocks of the overall system are covered for the TAB Team by these technology specialists. Key individual examples of these roles could be the Filtration Scientist, the Separations Scientist, and the Analytical Scientist. In this group is also the important bench scale engineer. This role is to be able to run mock ups of the larger scale systems to develop needed information to help solve the problems identified. The companion scientist role to support the bench chemistry to translate to the larger scale is the Scale Up Scientist. The technology team also includes the analytical method developers and referees for the analytical test method performance metrics for the system. The analytical generalists insure that the analytical methods that are being executed by the teams out in the units are validated and producing statistically stable decision-making information.

### **TAB Unit Operations Teams:**

The TAB Team will have subordinate unit operations teams. Each unit team shall have an Operations Coordinator who will be responsible for the detail day to day execution of the physical operation and material movement to enable the shakedown and testing and balancing runs as required. The TAB Unit Ops Teams will follow the Design Of Experiment (DOE) and iterative problem solving processes established and used by the TAB Team. The product of these runs is not only the physical material streams, but also the data from the shakedown and DOE runs. The response data for the runs must be produced at the different designed experiment factors levels to enable the development of the needed performance correlations for the systems. Whereas the TAB Leadership, Specialists, Technology and Attack Team groups will define the “what” is needed to be accomplished by the overall team, the Operations Coordinators and TAB Unit Operations Teams insure “how” the tasks are to be executed in order to meet the requirements of the defined runs in a safe and timely manner. The Operations Coordinators are responsible for the TAB Operations teams day to day staffing and control of the equipment and systems. The TAB Operations Coordinators are also responsible for the detail level communications and interface with all interdependent systems in the existing plant operations. The Overall TAB Operations Coordination Role insures broad and clear communication with all interdependent parties and stakeholders. In partnership with the Safety and Environmental Specialists assigned to the TAB Team, the Overall Ops Coordinator will be responsible to insure 100% safe and environmentally compliant operations of all TAB activities throughout the Testing, Balancing, Start Up and Commissioning effort.

### **TAB Operating Coordinators:**

Each of the three TAB Operating Coordinators is responsible for the day to day operational details for each unit. This role includes full understanding of the operation of the various pieces of equipment in the unit. The TAB Operating Coordinator’s role includes managing the CBA (Collective Bargaining Agreement) crew, insuring materials and supplies are available and usage and production is accounted for the runs, and the delivery of the OAG data summaries and the detailed run data reports to support the on-going TAB DOE efforts for each system. In addition, the TAB Ops Coordinators are responsible for the unit’s LOTO (Lock Out Tag Out), CSE (Confined Space Entry) and LOAF (Line Open and Flush) programs to enable the Attack team crafts and trades to install changes and make modifications to the system to insure the progressive completion of the needed fixes to the underperforming systems.

### **Operators:**

The unit operators are to be focused on being aware of the state of the operation from the field, anticipating needs to prevent breakdowns and proactively drive the continuous operation of the equipment by analyzing the process control data and knowing the normal operational characteristics of each unit. The operators are also responsible to respond to upsets and emergency situations quickly using the SOPs developed during the testing and balancing efforts and using the site wide SOPs long established at the site where appropriate. Operators are

expected to take routine samples at various points in the process and execute the operational control analytical methods from the operating floor. All operators will be Level 2 Validated on all test methods for which they are responsible for reporting. These samples will be refereed by the analytical group for the TAB Team to insure statistical stability in the decision-making data. The material operators are responsible for insuring that all materials management operations are completed to support the needs of the unit. This will include the physical labor to move, load remove and clean up materials as required.

### **Unit Engineers:**

Each unit engineer is expected to become a Subject Matter Expert (SME) in the operations of the unit that he or she is assigned. This role requires full understanding of the design details, complete understanding of the operation of the various pieces of equipment in the unit. The unit engineer will participate and eventually evolve to leading the performance based analysis, upgrade and maintenance of the unit. The unit engineer knowledge includes the interdependencies of the unit on the other interdependent units. The unit engineer shall be able to independently run, operate and troubleshoot the unit. The unit engineer acting in the SME role, will write the unit SOPs, develop and present the needed on-going training program content for that subject and its application to the unit. All maintenance and operating parameter management is the responsibility of the unit engineer to insure safe and optimum process performance to meet the expected product or intermediate specifications. The unit engineers will usually come from the pool of process and project engineers. Keeping in mind that many times these engineers are young and inexperienced, the role of Unit Engineer will be a significant opportunity for someone with a passion for learning to fill.

### **Design Engineers Transition to Unit Engineers:**

The Design Engineers (DE's) will play a transformative role as the designs are completed and implemented for the main builds. The Design Engineers have the responsibility to execute through the TAB efforts the testing and balancing procedures they require to establish system functional performance are executed. The Design Engineer first works with the Construction Management Build Engineer to install the system as per the presented design. Then it is the DE's role to insure that the TAB Team, of which they may or may not be a part, executes the needed functional and operational checks to demonstrate overall performance. The design engineers are finishing up the current list of fix its and they are then moving off the project, thus the unit engineer role will be staffed by engineers who transition and continue into operations after the operationalization turn over.

### **Automation Controls Engineers (ACEs) and Instrument and Controls Technicians (ICT's):**

One area of focus in any chemical plant installation is the high level of automation in the plant. The SCADA, HMI, instruments and valves are the eyes, ears, and hands of the process and the

operation must have immediate response to needs that arise. Separate ACEs (Automatic Control Engineers) and I&C Techs (instrument and Controls Technicians) will be dedicated to each of the TAB Ops Teams. These specialized individuals will be provided by the automation and controls system integrators and constructors supporting those services as part of the CM efforts. They will make a seamless transition to the TAB Ops Team.

**Operationalization:**

A performance criteria for each piece of equipment, system and unit shall be determined. These form the basis for completion and turnover of the item. In the case of a system, a prolonged run may be required whereas the timeframe can extend as operations normalizes the support systems for the unit. Plant wide, a qualification run shall be commenced when all the units making up the plant are signed over to operations. The plant wide performance run will then complete the operationalization of the system and start up is complete.