

“THE END OF THE BEGINNING”

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Abstract: Plant commissioning is possibly the shortest process in the asset life cycle of major assets. It is a critical time in the life cycle and a phase that frequently gets little attention. Never before this period and never again is there such a frenzy of activity and an accumulation of excited people with differing expectations and influences.

- What is involved in the process?
- When does commissioning start and when does it end?
- How do we manage this process to the best advantage?
- Is it too late to have any significant positive impact on asset life?
- Can poor commissioning have an adverse impact on reliability, integrity and life?
- How do differing expectations, influences and constraints affect the outcomes?

Commissioning is the time when you first see the conceptual plant in its physical form and realise what you have got, what you haven't got and the gap between what you wanted and what you will live with. It's a time of good news and bad news but also a time when good management can still have an influence on the ongoing asset life cycle.

Keywords: Commissioning, asset life cycle, commissioning process, reliability, asset integrity, expectations, constraints, project, construction, operations, commissioning management, operate & maintain, operability, maintainability, strategic approach, start-up curve, handover, documentation, training, schedule goals, sub-systems, commissioning phases, alignment, change management.

1 INTRODUCTION

Plant commissioning and project handover is possibly the shortest process in the asset life cycle of our assets. It is, however, a critical time and a period that can be quite confusing and difficult to manage. Never before this period and never again throughout the long life span of an asset is there such an frenzy of activity and an accumulation of excited people with differing expectations and influences.

- What is involved in the process?
- When does commissioning start and when does it end?
- How do we manage this process to the best advantage?

- Is it too late to have any significant positive impact on asset life?
- Can poor commissioning have an adverse impact on reliability, integrity and life?
- How do differing expectations, influences and constraints affect the outcomes?
- Do sound commissioning principles apply to ongoing minor projects, modifications and scheduled plant shutdowns?

Commissioning is the time when you first see the conceptual plant in its physical form and when you realise what you have got, what you haven't got and understand the gap between what you wanted and what you will live with. It is the moment of truth, a time of good news and bad news but also a time when through good management we can still have an influence on the ongoing asset life cycle.

2 COMMISSIONING & ASSET LIFE CYCLE

On a time scale Commissioning occupies a very small part of the Asset Life Cycle as shown in Figure 1 below. Depending on the industry and types of equipment, the commissioning period is often days or weeks in a total life cycle for the assets of several decades.

Generally the Asset Life Cycle is shown with the four main phases of Plan / Design, Construct / Acquire, Operate & Maintain and Dispose / Divest. Commissioning is usually regraded as part of the pre-operations phase but in fact it fills a very small fissure between the Construct / Acquire and the Operate & Maintain phases. This often means that it falls between two quite different groups (Construction & operations) even if it is managed and resourced internally in the operating organisation. Because of the short time available and its place in the big picture it is a process that is frequently under managed, under resourced, poorly planned, and given a low priority often leading to ongoing operational difficulties. Efficient and effective commissioning requires a strategic approach, clear thinking, a sound process as well as committed and dedicated management.

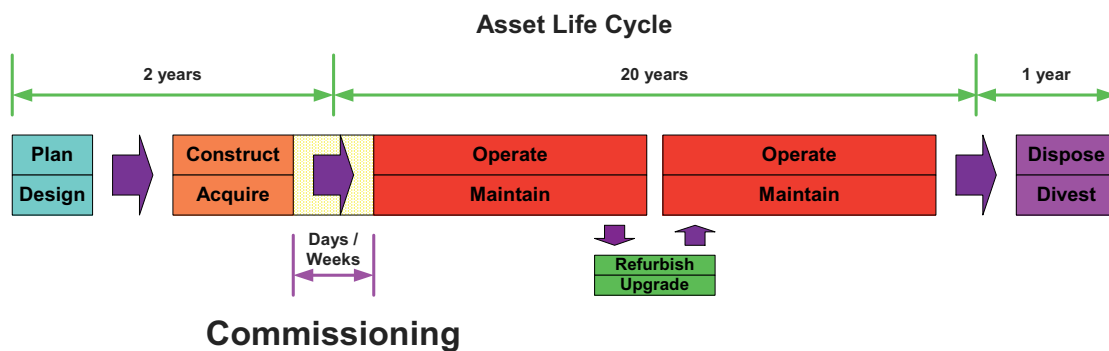


Figure 1

3 THE GOALS

- A strategic approach begins by establishing Commissioning Goals. These may include:
- Secure an efficient and quick start-up of production facility (start-up curve)
- Validate that the project construction team has installed according to the design requirements
- Ensure 100% mechanical, electrical and automation tests done before production start-up
- Clarify management processes and responsibilities before handover

- Demonstrate and document that all plant and process systems are operational
- Identify deficiencies and make corrections
- Adjust or modify equipment for best operability and maintainability
- Maintain cost, time, quality and OHS&E control to defined standards
- Phase out of construction and phase in of operations
- Complete handover documentation
- Ensure operations receive the appropriate hands on training and exposure during this time
- Progress commissioning in accordance with project requirements and long-term asset goals

4 COMMISSIONING PROCESS

Activities performed on a construction site after installation and before start-up are called **Commissioning**. The objective of the commissioning process is to bring the plant into production with a minimum of problems. During the commissioning there is a finishing of construction, and a concentrated focus of machine vendors and a phasing in of maintenance and production activities. This complex operation in the life cycle of a facility, when it changes from the Construction / Acquire Phase to the Operate / Maintain phase, is shown in Figure 2 below.

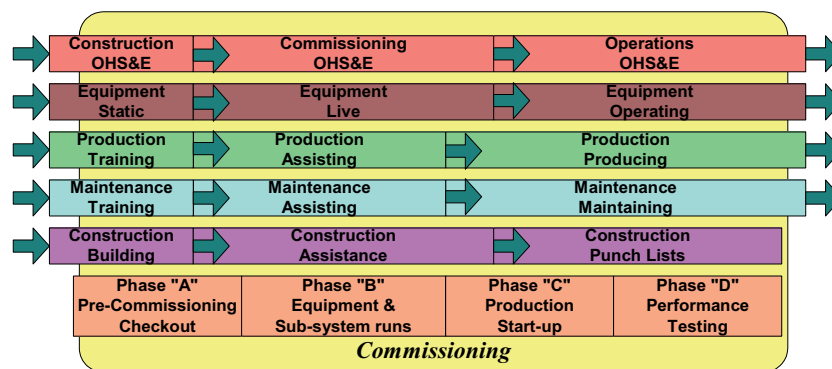


Figure 2

This picture illustrates that the roles of people involved in construction and plant operations change in nature during commissioning along with many key activities such as construction, maintenance, OHS&E. The installed equipment too changes from dormant to live, dirty to clean and untidy to orderly.

It is this phasing effect that makes it difficult to place the commissioning process in either of the main Asset Life Cycle phases on either side (Construct / Acquire and Operate / Maintain).

The commissioning process is depicted in simple terms in Figure 3 below. Although the process flow here is really concerned with the short term of the commissioning activity it can be seen from the list of inputs that the complete process of commissioning commences very early in design and is re-visited at critical stages during the Plan / Design and Construct / Acquire asset life phases.

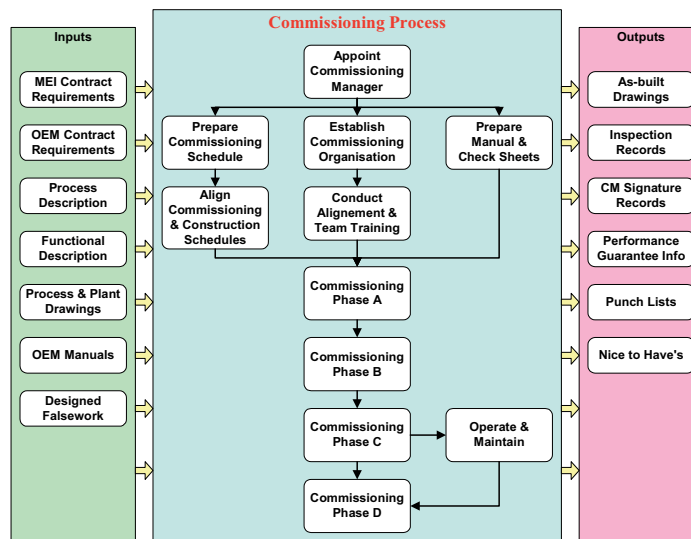


Figure 3

5 THE FOUR PHASES OF COMMISSIONING

Early planning during the construction phase and the preparation of an appropriate strategy for the plant commissioning is important to later success. This must be purpose generated to suite the circumstances and will obviously vary from project to project dependant on the plant configuration, contractual responsibilities of the parties and the requirements of the end user. A strategy for a large project for example may have, as it's key premises: -

- Divide the plant into manageable sub-systems
- Arrange the sub-systems into a logical sequence
- Assign target dates for the construction completion of each sub-systems
- Progress commissioning in pre-determined phased sequence
- Commissioned support systems (services) first followed by process systems

Having determined the overall strategy and established procedures for all parties to follow, the physical commissioning work can then proceed on a phased basis. Major phases for a process plant may include: -

- Phase A – **Installed Testing** - Normally the direct responsibility of the construction management company and / or the MEI contractors. This includes installation checks, point-to-point checks, system flushing and equipment rotation.
- Phase B - **System Checks** – The responsibility of commissioning team. Involves running equipment and conducting inspections and tests and checking operation to design. This critical phase would also be used as an opportunity for training of operators and maintenance personnel in the practical aspects of the new plant operation.
- Phase C - **Production** Dry and Wet Running. Still the responsibility of the commissioning team but a key time in the handover to operations
- Phase D - **Performance Guarantee** Testing. Carried out at appropriate times during the final stages of production runs or final operations.

A good method of illustrating and managing commissioning is to view it in four phases A, B, C & D as indicated in the Figure 4 below for a process plant (Pulp & Paper) commissioning:

| 5.1.1.1.1.1 5.1.1.1.1.2 PHASE | A Completion of Construction | A Installed Testing | B Water Runs | B Stock Runs | C & D Production & Start-up |
|----------------------------------|---|---|---|--|--|
| RESPONSIBILITY | Construction Suppliers | Construction Suppliers | Commissioning Construction Suppliers Operations | Commissioning Construction Suppliers Operations | Operations Suppliers |
| MEDIUM | None | None | Water | Stock | Stock |
| MECHANICAL, PIPING & CIVIL | Complete erection Grouting Cleaning Supports Painting Punch lists | Vendor checks Safety, guards Visual Internal inspections Drive belts Alignment Lubrication Hydrostatic | System flushing Isolations on Supplier tests Service tests Functional tests | Operation Supplier tests | Acceptance Handover Optimisation Performance Guarantee tests Full system start-up |
| ELECTRICAL | Installation complete Control circuits Power ready Point to point | Emergency stops MCC activated Rotational tests Dry interlocks Group starts | Interlocks Groups starts Motor loads Validate process description | Motor loads Interlocks Groups starts | Automatic ops |
| INSTRUMENTS & DCS | Installation complete Field checks complete DCS Installed Loop sheet verified Valves stroked Punch list | Loop tests Functional tests Dry interlocks Initial settings Site acceptance tests DCS complete | Interlocks Group starts Loop tuning Calibrations Validate process description | Consistency Calibrations Loop tuning | Consistency Calibrations Loop tuning Start up |

Figure 4

6 ORGANISATION

All stakeholders must feel ownership, take responsibility and facilitate the transition of ownership. This requires a sound, fluid, composite structure and the appointment of a suitably experienced “independent” Commissioning Manager. The manager should be a person experienced in project work as well as operations and have sufficient status to be able to manage all of the parties involved. A generic organisation chart is shown in Figure 5 below.

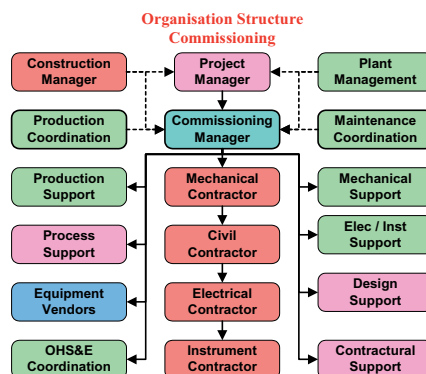


Figure 5

The commissioning manager key responsibilities include:

- Alignment of all parties involved in Commissioning of each major plant section
- Coordinate contractor commissioning assistance
- Manage changes required to process and equipment and as necessary call for revised HAZOP
- Manage the affixing of “Ready For Testing” tags and the issue of “Notice of Energisation” and all applicable OH&S requirements
- Conduct commissioning progress review forums
- Preparation of commissioning action lists
- Problem resolution directly or via appropriate referral
- Manage the handover from construction to operations
- Manage handover package (documentation) delivery
- Ensure environmental requirements are covered
- Ensure all parties work together for the same agreed goals

An early involvement is required for the commissioning manager so he can:

- Development of a comprehensive procedures manual incorporating all relevant existing operational and safety procedures
- Determine plant boundaries covered by the commissioning procedures
- Define and communicate the commissioning manager's responsibilities
- Coordinate the development of commissioning check sheets and books
- Define live equipment tagging procedures for those areas of plant not covered by the existing danger tag procedure.
- Clear determination of all relevant contracts clauses covering any aspect of commissioning
- Ensure new confined space and other procedures
- Determine required sequencing of runs, flushing, start-up etc
- Coordinate commissioning responsibilities
- Determine shift requirements
- Determine communication requirements (e.g. radios)
- Coordinate the preparation of a commissioning schedule

There are many players in the commissioning melting pot including:

- Contractors - mechanical
- Contractors - civil

- Contractors - electrical
- Contractors – instrument
- Project management & staff
- Design team representatives
- Equipment OEM & vendor representatives
- Government authorities
- Production personnel
- Maintenance personnel
- Training staff
- Auditors
- Senior management
- Public relations
- Visitors & spectators

The Commissioning Manager will coordinate and manage these individuals and groups who all come to the scene with widely differing priorities and backgrounds.

An early involvement of maintenance and production personnel, preferable those involved in design. This is important from a training perspective and also to get the early hands on experience necessary to continue into operations

6.1 COMMISSIONING ARRANGEMENTS

There is a range of normal project and operational management activities that continue through commissioning, however a few need emphasis during commissioning and a concentrated effort from the Commissioning Manager:

6.1.1 Alignment

Even if an alignment was conducted for the project at commencement it is important to have a specific alignment for the commissioning phase. This is an excellent way for the Commissioning Manager to kick off the process. It is important for all to understand how this time is seen through the eyes of others and to align the team to one set of goals and a common schedule

6.1.2 Communication

Extra effort on person-to-person communication and information circulation are essential to maintain a clear focus and to maintain efficiency across all work groups. Schedules are important as are punch list etc but time is too short to miss a daily all-in communication where issues and priorities can be raised

Daily stand up communication meetings to keep all stakeholders informed, decide on the daily priorities in accordance with the schedule and to allocate small teams or individuals to resolve issues that arise

6.1.3 OHS&E

A critical topic for the commissioning phase and as a minimum must be discussed at the daily meetings. Apart from the work complexity, housekeeping challenges this is a time of significant change from project to operational conditions.

Tagging of equipment to ensure that visually all site personnel are aware that equipment is changing from dormant to active. The concept is to have site equipment tags to inform all parties of the condition and inspection stage of every piece of equipment and to have an overall picture recorded progressively in a master folder.

6.1.4 Training

Production and maintenance training would have commenced well prior to this time. It is important however to capitalise on the unique opportunity to understand the new equipment from personal learning and technical aspects, data collection, instrument settings performance measurement and vibration signatures etc.

A wide range of personnel can get experience and learning by being involved with equipment activities such as equipment numbering and tagging, pipeline identification, checking installation and equipment to drawing and inspecting for operability and maintainability. Allocating appropriate technicians and operators to OEM's is critical.

6.1.5 Procedures Manual

Although each project is unique a procedures manual should include the following key sections: - introduction / purpose / structure, safety, isolations (testing & operations), confined space, environment, commissioning procedures, commissioning schedule, organisation, responsibilities & relationships, communication channels, handover, regulatory requirements, general procedures, vendor requirements, contacts etc.

The procedures manual can be combined with the master handover records file required to capture all inspection, test and defect information.

6.1.6 Schedule

It is important to have a schedule for all commissioning activities specifically construction, commissioning and production. The schedule will allow for inspections of the installed equipment, actioning of high priority punch list items and dovetail in with the completion of construction schedules that may continue on into the commencement of commissioning

The Commissioning Manager will manage the process to ensure that the work is carried out systematically and in the correct sequence. The sequence is important to keep personnel focussed and also to allow for system operational constraints that require some equipment and systems to be functional before others. Generally services need to be commissioned first

6.1.7 Change Management

Commissioning is the most comprehensive change management exercise that will be undertaken by a manufacturing organisation. Changes will impact on, or be influenced by, all areas of business including:

- People - recruitment, training, technical and operational safety knowledge, and communication.
- Process - design, regulatory, process descriptions, safe operating limits, and abnormal operations.
- Assets - physical changes, design standards, regulatory requirements, CMMS, accounts, procedures, records, maintenance regimes.
- OH&S - legislative (e.g. MHF) requirements, Safe working environment, dangerous goods
- Environment- approvals are gained and records modified
- Business - objectives, economic or on non-economic justification
- Procedural - codes, standards (internal and external)
- External - quality of feedstock, delivery arrangements, transfer equipment, upstream process changes, services supply, land use change, addition of plant or changes to nearby facilities.

It is important to have change management processes in place. Clearly some of the change process commences very early in the project, however it is during commissioning that it all becomes critical.

It is important to have a review and approval / rejection process for plant changes (modifications) that are raised. As a minimum they should be categorised into must do, do at some time and "nice to have's" to be listed for review and justification. Whilst not forgetting the project imperatives of cost, time, quality and scope any defects or unsatisfactory operability and maintainability aspects will most likely remain with the assets for many years.

7 WHERE DO WE GO WRONG?

7.1 People & Processes

Many of the problems in commissioning emanate from operations and project management not giving the commissioning processes and the commissioning team sufficient importance, authority and attention. This results in organisational and people aspects not being effectively controlled. Some of the key aspects are:

7.1.1 Alignment & Involvement

Not having an alignment or not have a complete (all stakeholders) effective alignment severely impacts on the success of the commissioning process.

7.1.2 Involvement

Not having the right people available or dedicated to the project at the right time. It is important to involve production and maintenance people from very early design. Unfortunately this involvement is not always seen as a priority at that time. This extends to not making a commitment in design phase or then again at commissioning to dedicate operations maintenance and production personnel to the project. Commissioning is a time where a large number of tasks must be completed. It is also the best time for training. Operations people involved at this stage get an unparalleled learning through experience opportunity that cannot be equalled late in the asset life. There is also the opportunity to influence the equipment and process that is finally handed over.

7.1.3 Communication

Commissioning is not a controlled ongoing situation that most are used to in industry and neither is it a controlled steady change as in a project, rather it is a constantly changing environment with errors, omissions, oversights, defects and physical changes coming to the forefront. There can never be enough communication, particularly face-to-face and particularly between combatants that may normally communicate only infrequently. Special effort is required to achieve an integrated effort from all of the participants and this area requires alert commissioning management.

7.1.4 Training & Understanding

The introduction of bad practices through low involvement from the early project conception and poor training prior to and during commissioning. Irreparable damage can be caused to machinery by operators and maintainers not running the plant the way it was designed to be operated. This leads to frustration, breakdown, and incorrect operations leading to very early requests for plant modifications. “Read the instructions first” still applies.

Formal training is essential there is no substitute for a wide range of plant people developing an in-depth understanding of the equipment and production process design and how it is meant to operate.

7.1.5 Process & Procedures

Operations management often assume that commissioning will occur as a natural part of the construction project, and what they miss will be picked up once it is operational. They frequently fail to realise that there are some very specific processes that must be put in place and managed. An organisation is only as effective as its processes. The process is best presented to the complete team in the form of a Procedures manual.

7.1.6 Schedule

Most participants enter the commissioning phase with their own departmental schedules that they have been working to, particularly project schedules, or the schedules that are in front of them, notably the forward production forecasts and associated budget promises.

7.1.7 Change Management

Regrettably most plants commence operations with inadequately prepared work teams, particularly from the aspect of understanding the changes and the differences to the old plant they are so familiar with. Engineering and maintenance documentations and technical data frequently is slow in being delivered and inadequate. This is compounded by the operations people not being mobilised in sufficient time before operation commences.

Inadequate data and documentation emanates from not tying down the documentation requirements at the design phase and not specifying documentation and schedule requirements at negotiation and purchase time.

7.2 Engineering & Equipment

Failure to set up the commissioning team adequately will result in short cuts being taken often resulting in damage to machinery occurring, often unnoticed at the time. Below are a few examples of minor problems that can have lasting deleterious effects on the plant, subject operations people to unnecessary personal risk and increase the ongoing cost base:

7.2.1 Design

- Valves that need to be operated frequently being placed above floor access level and no fixed means of access.
- Poor lighting in dark corners
- Pumps positioned so that piping prevents crane access for maintenance
- Long equipment aligned incorrectly for 2 hoist crane lifts
- Poor access to key pieces of equipment resulting in excessive manual efforts for maintenance and operations

7.2.2 Construction

- Grouting installed to ensure water is trapped and diverted in under sole plates – unfinished work
- Hurried appearance painting in place of protective coating
- Improper line flushing and screening with foreign material remaining in the systems
- Pipe supports not in place
- Forgetting to grease, not recognising that some remaining orifices are in fact grease points or over greasing

7.2.3 Inspection & testing

- Sealing water systems forgotten and not operational
- Plastic, wood, oil dry in the wrong places so that it can enter the process system

- Leaving an oil filler cap of the hydraulic system and undoing all the pre-commissioning filtration and reducing the equipment life.
- Making assumptions on equipment condition before inspection and testing is complete
- Failure to run in equipment such as seals

Significant design problems that do not have an immediate effect on the plant operation is unlikely to be corrected at commissioning and will have a detrimental effect on life cycle operations thereafter. Other items, such as valve access, can be corrected during construction and during the frenzy of project completion at commissioning. This can only occur by having some budget provision and people with appropriate experience “on the spot” to pick up these items and initiate the corrective actions.

8 WHAT CAN WE DO

Is commissioning the end of the beginning or the beginning of the end? It could be the start of premature asset degradation if errors occur and are not noticed during commissioning, or if poor start-up practices are adopted, even if unwittingly.

Good start-up and long asset life can be assured by having experienced maintenance and production people involved in a project from a very early design stage. This needs to be seen as a priority from an asset life cycle perspective. Although the vast majority of asset life cycle costs occur during the long (20+ years) operate and maintain phase the opportunity to influence this in terms of maintainability, reliability, operability, integrity and life is at critical times during the design phase. There is a further very small but important window of opportunity to further this cause during the phase of commissioning. Regardless of how many drawings we study, even three dimensional walk throughs, there is no substitute for seeing the new plant in real life and making final corrections within the project constraints.

Sound commissioning principles certainly apply to ongoing minor projects, modifications and scheduled plant shutdowns. In many industries shutdowns are infrequent and of relatively long durations (weeks) resulting in a natural tendency to employ project management techniques and sound commissioning and handover processes. Other industries, however, have more frequent and smaller duration shuts (hours / days) and the pressure to produce often results in the sound commissioning principles being bypassed. Unfortunately this has the same effects as project commissioning in that it will affect the performance and life of the assets. The same sound principles need to be applied to these operational aspects including the appointment of a Shutdown Manager (cf. Commissioning Manager) for all shuts. Even the smallest of “projects” require the same change management and commissioning principles and practices.

The most important thing we can do is to educate all stakeholders, particularly senior management, in the importance of life cycle considerations and the importance of each phase. Project specialists are notoriously poor at developing any understanding of the life cycle. Their focus is different for obvious reasons and centres on the project time and cost budget. It is often said that quality is a given but this is only so if the correct input is applied. In all aspects it is important to take a long-term strategic asset view to achieve best benefit from the commissioning process.