The Chemical Engineer

Can we build it? Yes we can...

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spgl
Managing Quality
Improving Performance

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... but it has to be top quality and cost effective, say **Jay Lad** and **Bruce Beck** as they examine trends in construction, the key to successful commissioning and time to market

IN TODAY'S economic landscape, there is great emphasis on assuring 'return on capital invested' and 'value for money', particularly in large-scale capital projects. This pressure is especially acute for complex capital-intensive projects with long lead times in the energy, technology and pharmaceutical market sectors.

Although companies, governments and investors cautiously continue to commit capital, there is more pressure today than ever, especially from a field-execution perspective, to mitigate risks, control or conserve cash, accelerate schedule, manage quality and excel at project turn-over. In addition, good operability, cost-effective maintenance and the entire 'asset life' are becoming common key-performance indicators for the value of the investment.

Large programme delays, costly over-runs and poor operability/reliability resulting from poor quality are no longer acceptable in today's marketplace.

For many years and with dramatic cost to our economy, the construction sector has been struggling with field-quality issues, resulting in commissioning delays and, ultimately, facilities with poor operability and reliability. This cost, however, could potentially be reduced significantly if the industry was to embrace the concept of 'quality assurance' that has been used with great success by other sectors of the economy.

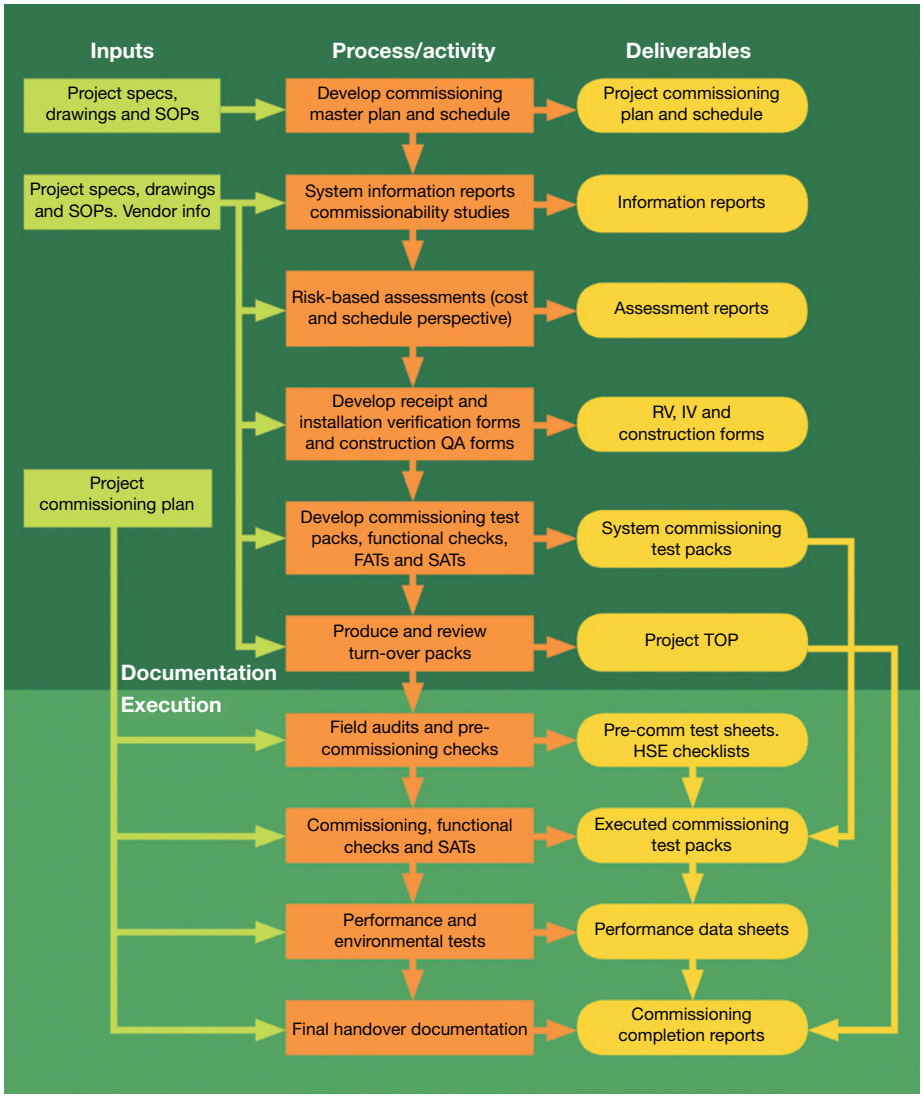

Figure 1: Commissioning flow chart

background

Industry today is generally well served from a design/engineering perspective, as it has many design guides readily available. Designing quality into a facility and, indeed, the concept of 'quality by design' (QbD) has become the standard and the norm across many market sectors. Also, the cultures of good engineering practice (GEP) and good documentation practice (GDP) are well-established concepts across many industries.

However, a well-designed facility, with excellent specification and engineering, has little value if the design is not properly translated into the construction and start-up of the facility.

There are many different delivery methods for capital projects. However, most approaches tend to involve taking a design and breaking it down into manageable packages. The constructor then either chooses to self-perform these packages, sub-contract it fully or, most commonly, does a combination of both sub-contracting and self-performing.

One would expect the self-performed elements of the project to be of a predictable quality. However, the quality of sub-contracted elements may vary hugely depending on the selection of the sub-contractors.

Therefore, the effective selection and management of sub-contractors is crucial to the successful outcome of a project.

the field game

Unlike design/engineering companies, whose focus is on QbD, construction companies tend to be very cost and time driven and, therefore, their focus is on task completion and safety. Ideally, field safety and quality should be combined to deliver projects with zero accidents and zero defects. Indeed, many construction companies do not have a quality manual/programme and often fail to see the intrinsic link between quality and safety.

At the outset of a project the appropriate level of quality must be determined for every phase. This is usually established for the engineering phase. However, it is often overlooked for the construction and commissioning phases, which are probably the two most critical phases that impact operability, availability, reliability and maintainability of a facility.

A good constructor should normally have a commissioning plan developed at the pre-construction stage. The objective being that the most critical and hazardous parts of the project are fully mapped out and costed, even before the construction has started (see Figure 1 for an approach to commissioning).

However, a well-planned commissioning programme, with excellent protocols and check sheets, is of little value if the construction of the overall facility is of a poor quality and littered with defects. Therefore, the overall commissioning effort will ultimately prove to be more dangerous, troublesome and costly.

It is clear from the above that, at the pre-construction stage, the approach to construction quality and commissioning should be fully established in a construction quality and commissioning plan. The level of quality/checking to be applied to the project should be clearly laid out and fully understood by all parties.

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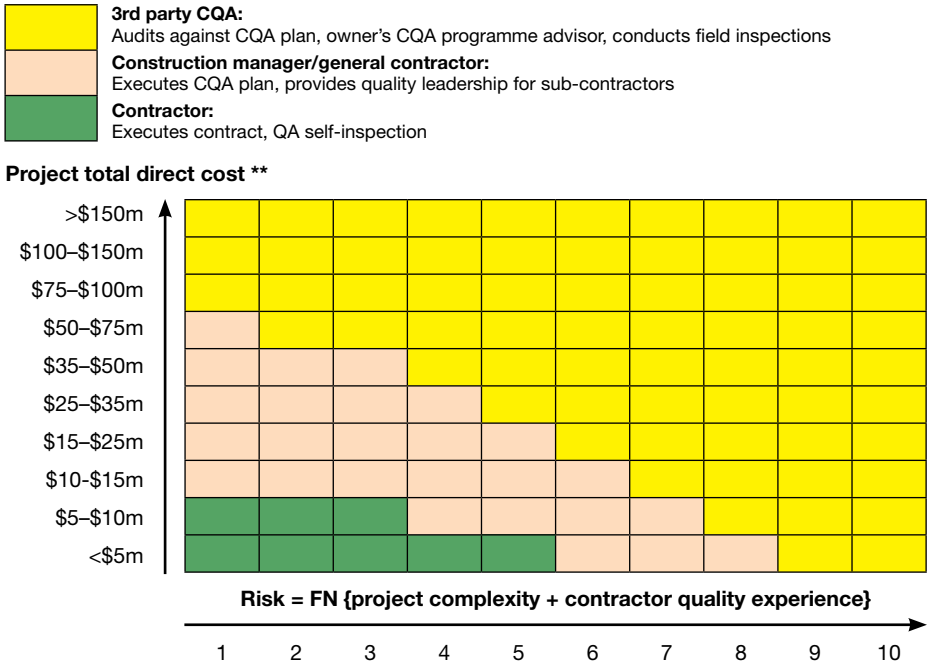
Figure 2: Project scaling



(Identify values for project complexity and contractor quality experience, and add together)

Project complexity (examples)

Parking lot, landscaping	1
Minimal building construction, installing package equipment	2
Warehouse with temperature control, laboratory, administration facilities	3
Medium-sized process facility, non-regulated industry	4
Large scale, complex, regulated process facility (eg pharmaceutical, biotech, nuclear etc)	5

Contractor quality experience

Industry leader/ISO 9000 certified	1
Projects with alliance contractors	2
Projects without alliance contractors	3
Projects with limited owner experienced contractors	4
No previous owner experience	5

**** Project total direct cost only includes shell, building and process equipment**

quality

Establishing a 'culture of quality' within an organisation can be quite cumbersome because it requires a complete turnaround in corporate culture and management approach. It's also a slow and gradual process requiring substantial investment and commitment that may not always make commercial sense in the construction industry for one major reason: 'organisation stability'.

The construction industry has a high number of collapses, especially during a downturn in the economy. Thus, commitment towards quality strategies and policies that may take several years to provide 'pay-offs' may be perceived as futile or a misdirection of resources. As compared with the head office, the construction site is transitory, where teams are specially formed for a project and which may cease to exist after contractual obligations end. This situation is compounded by the fact that the implementation of quality in construction requires the selection of the appropriate sub-contractors who would commit to the quality process and develop a true quality attitude.

Therefore, depending on the size/complexity of the project, a logical solution to this challenge would be to have the construction quality function managed by a third party. This should be one who really understands the purpose of the facility, its specific operational/maintenance needs and can bring the appropriate level of quality to the construction phase (see Figure 2).

Is it the architect/engineer or would it make more sense to have a commissioning firm work closely with the construction company to properly integrate quality into construction, and leverage this into commissioning to reduce 'time to market'?

A commissioning firm that understands quality and its application in the field as well as commissioning requirements may be ideally placed to take on the role of 'construction quality assurance' (CQA) manager. If executed properly, not only can they carry out this role in a cost-effective and independent manner, but also add great value to both the constructor and the owner.

So how can a commissioning firm deliver the right quality to the construction/commissioning activities in the field? This can be achieved by implementing a CQA programme, based on the principles of GEP and GDP to suit construction as outlined below.

CQA programme

At the pre-construction stage of a project, a good construction manager will normally prepare a construction quality plan (CQP), attempting to document the key steps necessary to deliver a building/facility that is fit for its intended purpose. However, a plan is simply just a plan and, unless it is part of an overall integrated field-quality assurance programme, it often proves to be ineffective. Quality by inspection is limited and unless an integrated approach is adopted, success is a probability rather than a certainty!

A CQA programme should aim to apply quality concepts and practices to the construction activities to ensure that the facility is delivered on time, as specified, defect free and in an operable state. One of the primary objectives of the CQA programme should be to raise the importance of quality and self-inspection/testing to the constructor/sub-contractors in order to prevent deficiencies, minimise defective work and strive towards a zero critical-items punch list. However, the overall responsibility for the construction quality should never be removed from the constructor/sub-contractor.

A good CQA programme should allow owners to use contractors with varying levels of field-quality expertise, yet be assured that

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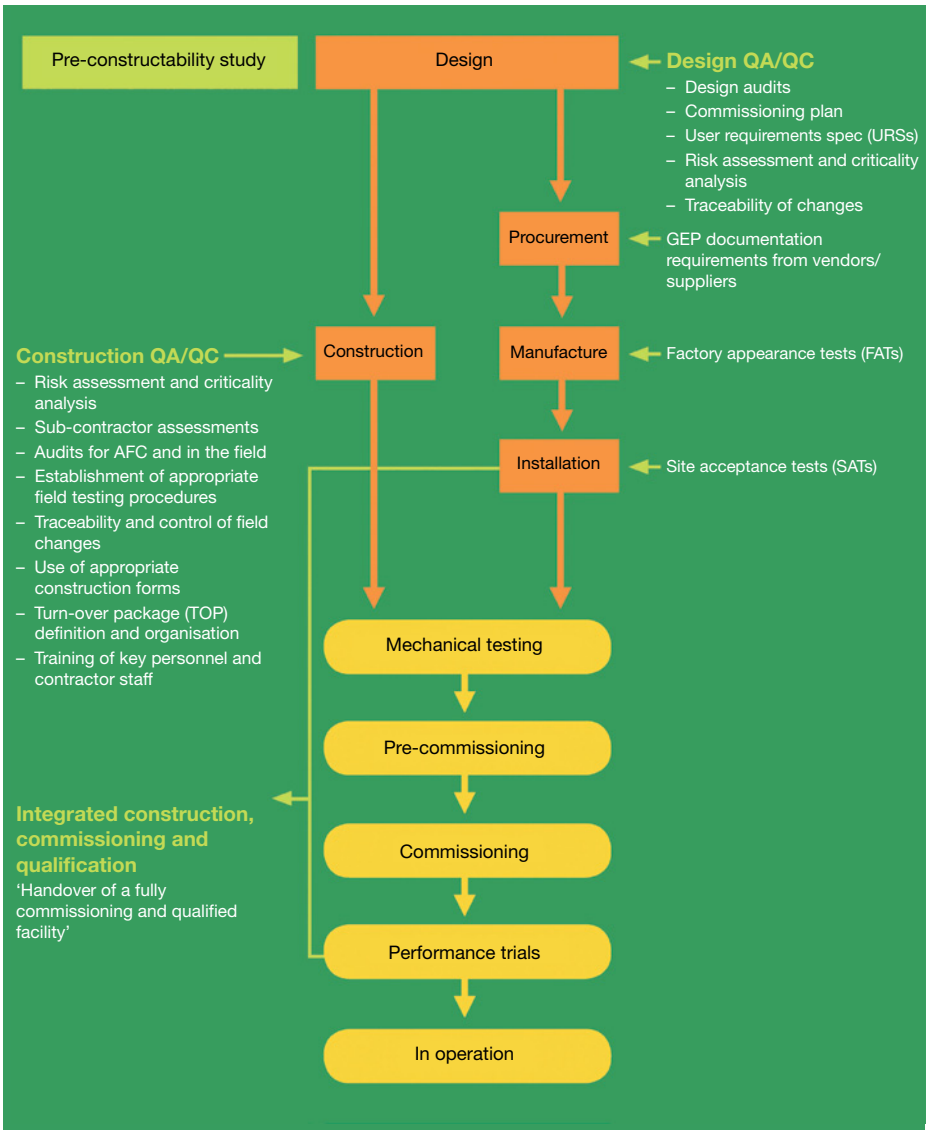

Figure 3: Approach to project quality

the outcome is a trouble-free commissioning/start-up, ensuring a reduced 'time to market and, ultimately, a return on capital invested and value for money!

The CQA programme should form the basis for integrating construction with commissioning, the objective being to reduce cost and time to market through a number of critical steps as identified below (see Figure 3):

step 1. risk assessment and criticality analysis

At the start of a project, it is important to identify and understand critical aspects of the project that will impact schedule and cost.

Risk analysis is often carried out at the design phase of a project, by the engineers and owners, usually from a design/engineering perspective. The result normally captures the client's expectations by classifying systems into critical-impact systems and non-critical systems. This is significant because critical systems, or higher-risk systems, require a higher level of documentation, field inspections and testing.

However, it is just as important to identify and assess the risks to the project from a field-execution perspective. Therefore, at the pre-construction stage the risk assessments should also be carried out from a field perspective, identifying/assessing the criticality and interdependencies of systems, not just from a quality perspective, but also from a commissioning and schedule-impact perspective. This should apply to all systems and be carried out by the CQA manager, constructor and the client. A risk assessment that is executed from both a quality and schedule perspective will allow the field team to identify and prioritise quality/schedule-critical aspects of the project.

step 2. sub-contractor assessments

Once the key systems in the field have been identified that will significantly impact

schedule/cost, it is essential to audit the contractors responsible for these systems, in order to ensure that they have the appropriate quality systems, commissioning plans, method statements and check sheets to prevent deficiencies and minimise defective work. Understanding the gaps/deficiencies of the key contractors early in the project and implementing the appropriate corrective actions will be crucial to the overall success of the project.

step 3. audits for AFC (approved for construction) drawings, field inspections and reporting

Compliance audits are normally carried out at the design phase of a project, by the engineers and owners, usually from a GEP perspective. The result normally captures a lot of potential issues, largely from a safety, regulatory, operability and maintainability perspective. However, often little or no auditing is carried out from a construction/field-execution perspective.

The CQA manager should perform field audits, focused on high-risk/critical systems that have been identified during the risk and criticality analysis. The primary objective of the field audits should be to highlight construction-quality issues that may impact start-up/commissioning and hence the overall project schedule. The field auditing should be supported by a formal process to record, manage and resolve issues.

Ideally, the CQA manager should also perform compliance audits on 'approved for construction' documentation prior to the start of work as well as review bid packages to assure that the requirements of the owner are included and delivered. This is applicable to both vendors and sub-contractors. Regular meetings should be held with vendors/sub-contractors in order to ensure that specifications are understood and appropriate procedures are in place.

step 4. establishment of appropriate field procedures

The CQA manager should identify and establish appropriate field-testing procedures necessary to execute the project. The field-testing procedures should include inspection plans, commissioning protocols, test sheets, method statements, punch lists as well as procedures governing documentation format, storage and distribution.

step 5. traceability and control of field changes

During the design/engineering phase, design changes are usually managed and controlled extremely closely. However, the management and control of field changes is usually overlooked. Often there are more changes in the field than in the design phase. Therefore, traceability and control of field changes should be a high priority for the overall project team, because field changes may compromise commissionability/operability, safety, quality, schedule and costs.

The CQA manager should ensure that field changes are properly assessed from a safety, commissionability/operability, quality, schedule and cost perspective. He/she should also ensure that the field changes are recorded, properly documented, dated, assigned accountability, audited, signed and properly filed. 'Red Flag' items should be prioritised for action.

step 6. use of appropriate construction forms

All check forms to be used for system fabrication, installation and testing should be in compliance with GEP requirements. The forms should also be checked for suitability and contents because they may be used as leveraged data to the commissioning phase, thereby eliminating duplication of effort.

step 7. turn-over package (TOP) definition and organisation

The CQA manager should develop the turn-over package (TOP) procedure, ideally at the pre-construction stage of the project. This should be discussed and agreed with the constructor and sub-contractors because they will, ultimately, be responsible for assembling the TOPs. The CQA manager should audit the development of the TOPs and conduct a final review at the hand-over stage. This should guarantee a high-quality package, which should include all required up-to-date documentation from vendors, engineering, construction activities, procurements etc.

step 8. training of key personnel and contractor staff

The quality culture of 'right first time' should be developed within the project team through a training programme. All key construction personnel and sub-contracting staff directly involved in completing documentation for project TOPs should be trained, as a minimum, in GDP as well as relevant standard operating procedures and field procedures established for the project.

Figure 4: Construction quality modelled on safety programme

summary

A good CQA programme should facilitate proper construction turn-over and ensure that systems are ready for commissioning. Ultimately, a facility with good construction quality and minimal defects is more likely to have a smooth and trouble-free transition into the commissioning/start-up phase of the project.

It is also important to ensure that the CQA programme is not confused with the field-safety programme. In fact, both programmes should run parallel and mirror each other, aiming to deliver a facility with zero accidents and zero defects (see Figure 4).

conclusion

The selection of a good constructor is obviously very important. However, selecting a third party to perform CQA early on in the project will have a very significant impact on the project's outcome. A clear commissioning strategy, underpinned with a good CQA programme, established at the pre-construction stage of the project, should help translate good engineering design into field execution/construction and help alleviate many of the problems encountered at the back end of a project. In the final analysis, especially from an owner/investor perspective: "A successful project is where a facility reaches optimal operation in a safe manner and in the shortest possible timeframe, achieving high availability and reliability during the first-cycle operation, maximising cash flow through the first-cycle operation!" **tce**

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