Keeping up quality

Samuel Blaser, AST Turbo AG, Switzerland, discusses quality challenges on large rotating equipment turnarounds, and the economic benefits of a structured QA/QC approach.

The rotating equipment maintenance business is changing globally and most significantly in North America. The environment has changed from 'hardly any new plants within a decade' to 'several new major plants in a year', from 'peak oil scenario' to 'shale oil abundance'. At the same time, the industry is losing a generation of experts; engineers and specialists. The turnaround cycles have been extended from historically 3 - 5 years to up to 10 years. This is further limiting individual experience, which is a significant factor. Consequently, maintenance team members are in place for many years before they experience their first major turnaround event. These members are frequently promoted and therefore are not granted the opportunity to contribute the experience gained towards a second event. A similar scenario is present within the organisation of many service providers. This leads to a situation where contractors may have performed large turnarounds as a company, while the number of individuals that can actually run field projects competently and with solid experience gets smaller and smaller. Therefore, the risk of experiencing poor results is increased in all key aspects of the turnaround: safety, quality, schedule and costs.

All these aspects require a closer look at how quality assurance and quality controls (QA/QC) on large turnarounds are being planned and implemented. This article provides an overview of the four key tactical areas, including the associated tasks, for quality management during all phases of a turnaround.

Table 1. Excerpt of a project quality plan (propylene compressor rotor overhaul)

Item	Task description	Reference	Category	Date	Sign off			Remarks
					Contractor	AST Turbo QA/QC	Customer	
1	Disassembly							
1.1	Measure coupling free float before disassembly	OEM Drawing XX-85093-001	V		☐	☐	☐	
1.2	Identify coupling match marks	Good practice	V		☐	☐	☐	
1.3	Verify that locking screw is properly tightened on turbine end coupling	Good practice	V		☐	☐	☐	Picture to be taken
1.4	Perform axial float check	Component drawing	V		☐	☐	☐	
1.5	Once bearing housing is removed on both ends, check rotor runout. Measures to be taken on areas where vibration probes read	Good practice	V		☐	☐	☐	Requested by customer
1.6	Verify pinch between bearing retainer and journal bearing (both ends)	OEM Drawing XX-85095-002	V		☐	☐	☐	Issues with lack of pinch was noticed on previous inspections. Bearing retainer splitline was machined to improve it
1.7	Check journal bearing clearance (both ends)	OEM Drawing XX-85077-001	H		☐	☐	☐	By Lift Check Customer signature is required
1.8	Check rotor running position on active side	OEM Drawing XX-85045-003	V		☐	☐	☐	
1.9	Check and mark orifice installed in the oil supply line	Good practice	V		☐	☐	☐	
1.10	Check and mark seal oil bypass orifice	Good practice	V		☐	☐	☐	Record the orifice diameter and include it on the report

Observations over the last few years

Over the past few years, the petrochemical business was on the downslope with relatively few new plants brought onstream. There were multiple overhaul strategies, some more and some less successful. Focus was placed on quality; first supported by ISO9001, then health, safety and environment (HSE) supported by OHSAS 18001 and similar standards.

Good excuses were, however, readily at hand when attempting to justify schedule overruns or extra costs incurred during turnaround execution, especially those related to rework due to lack of quality and poor planning.

Starting projects with poor planning and preparation efforts, as a consequence of falsely perceived cost saving measures taken by project management teams, leads to much higher costs when trying to react during the execution phase. A clear example of poor planning are schedules where activities requiring the same resources are planned to take place in parallel.

Rework due to lack of adequate quality control during the initial implementation attempt became a repeating occurrence and the figure of a QA/QC supervisor started to appear on turnarounds. The QA/QC supervisors were, however, only involved during the execution phase of the project and their role was limited to confirming that measured values were within tolerances specified. This effort notwithstanding wasted time was still an issue on turnaround executions due to repetitive discussions between the QA/QC supervisor and contractors related to unclear procedures and lack of well defined acceptance criteria.

Warranty claims started to be raised by unsatisfied customers more frequently and discussions between the involved parties began to extend over long periods of time, while the machine continued to operate with the issue under discussion. In several cases the only way to implement a corrective action required shutting down the machine, which resulted in costly losses to the end users.

The current approach with mixed and often unclear responsibilities between customer supervisor, OEM technical advisor and labour contractor may not work anymore.

Overhauls within mega plants can no longer be based on 'tradition' and historical 'war stories'.

The new approach

The integrated QA/QC scheme has been proven to be a successful model. Integrated means that a dedicated QA/QC team follows the whole event, including all planning and preparation. The QA/QC team may include the customer and/or contractors that work together as a team. The new approach requires specific decisions during the strategic planning phase. Key criteria for the selection of QA/QC team members are that they have profound rotating equipment overhaul experience. They must be prepared to follow the high pace of the turnaround activities in order to foresee the next steps before they occur. The objective is that the QA/QC tasks result in improvement of overall progress by minimising undue hold times.

There are four key tactical areas that will be covered in more detail in this article. All of them need to take place at the right time to be effective. The foundation for a successful turnaround QA/QC scheme of rotating equipment in a large plant will be ensured by thorough and careful definition in these areas:

- Cold eye review.
- Pre shutdown site audit.
- QA/QC during the turnaround.
- Recommissioning support.

Each of these areas must be treated separately.

Cold eye review

- Review project scope, expectations and risks.
- Define roles and responsibilities.
- Allocate resources and understanding logistic challenges.
- Set procedures and acceptance criteria.

Early preparation means to start planning the event 12 - 18 months ahead of the turnaround. A cold eye review scheme should be put in place early to ensure a seamless approach. The contractor/OEM, the customer and the QA/QC team will ideally attend these meetings.

The cold eye reviews look at all logistics, quality and HSE aspects of the project, going from defining the project scope, understanding stakeholders expectations, and identifying project risks; passing through assigning responsibilities, allocating resources and developing quality and HSE project plans; and ending with assurance that all action items are implemented on time.

Understanding that each project has its own particularities, and allocating the right resources for fulfilling the activities on the job scope, is critical for the success of the project. The expertise and inputs of the QA/QC team on this matter can significantly support the project management team during this process. For example, the project schedule is developed during this project phase. A realistic schedule, aligned to site conditions and work scope, is important for the proper tracking of activities during the execution. The QA/QC team can provide inputs on the duration and sequence of activities as well as identify conflicts of interest between work activities (e.g. two activities scheduled in parallel that require the same resources). In a further step the QA/QC team must be capable of sharing lessons learned, best practices and productivity measures from other events in order to improve the project schedule.

The management of quality on a turnaround starts during the preparation phase by setting and matching inspection procedures, acceptance criteria and customer requirements for the activities to be carried out. Journal bearing clearances will be used here to highlight the importance of quality planning.

The quality plan typically foresees a hold point for journal bearing clearances. The QA/QC inspector is called to the site when the bearing is measured and the clearance record completed. In reality the quality plan should detail the method statement (e.g. lift check, plastigauge, component measurement, with or without correction factor). On the one hand this is important in order to define the expectations. On the other hand it is just as important that the method is clearly understood and scheduled accordingly. For example, a component measurement check requires much more time than a lift check. In the worst case, the correct method to be applied is being discussed and argued by the 'experts' during the turnaround at the expense of further unnecessary time loss. This article does not discuss which method is appropriate. It addresses the fact that these methods need to be defined mutually during the preparation phase of the project and then communicated to the execution team.

The next detail that needs to be looked at is acceptance criteria for reuse of components. While some customers may decide to replace all bearing as a matter of course, others may want to take a more economical approach and define engineered testing and acceptance criteria for 'reuse/renew' criteria. The applicable criteria need to be agreed upon before the event to avoid abusing costly shutdown time to discuss matters that could have easily been clarified beforehand.

This bearing example is just one of many. It was chosen as it easily explains the impact of poor planning. There are many others: what components require NDT, and using which method? What is the acceptable wear pattern on steam valve plugs and seats? When are they replaced, and when are they reused? These decisions need to be put in correlation with the contracting strategy. A contractor may be reluctant to replace some components. Reuse of previously installed parts may be less time consuming and less risky to his turnaround schedule. This may result in premature failure and a reduction of the reliable run time of the unit. Other parts maybe changed out as a matter of course. This sometimes happens without engineered justification and may result in unexpectedly high spare parts consumption.

A well balanced quality plan incorporating method statements and engineered acceptance criteria allows to plan the project realistically. It avoids unnecessary and timely discussion during the outage itself and has a positive influence on the reliability of the equipment and may reduce spare parts consumption. The ownership and source of all documented procedures, acceptance criteria and the interfaces required for each document must be defined and agreed to by the management team in the early planning phase.

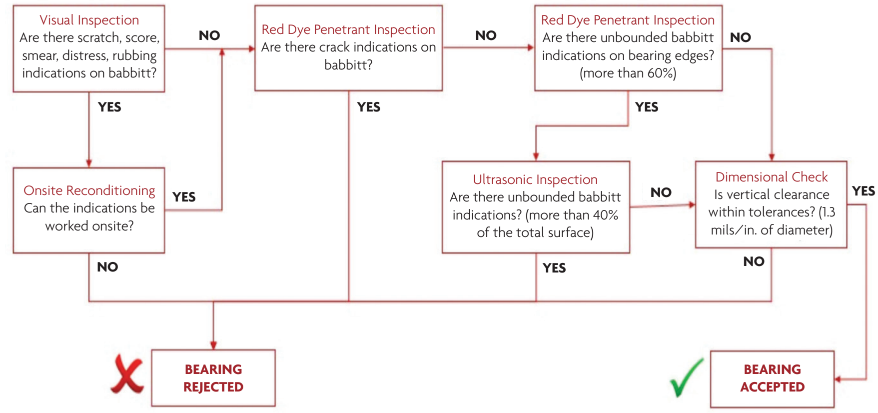

Figure 1. Decision making tree for an elliptical journal bearing inspection.

Figure 2. Reoccuring failure can be avoided: oil leak through oil deflector horizontal joint.

Involving the QA/QC team from the preparation phase is fundamental for the success of the turnaround. The active participation of the QA/QC team during this phase must be considered as an investment that will pay dividends during the execution phase.

Pre shutdown site audit

- Review and audit operating parameters before shutdown.
- Independent interviews: operations, maintenance and reliability team.
- Site survey around running units.
- 'Paint a real picture' of the running units based on all available information.

This activity is typically of short duration and will provide the last technical information about the condition of the units before they are shut down for overhauling. This activity is important to ensure the right focus is put on areas that require special attention.

This may be as simple as addressing leaking coupling guards or vibrating/loose valve linkages but may proceed into the area of performance issues on turbines and/or compressors. It is important that these audits and interviews are carried out by independent experts that know what to watch out for and what questions to ask at which level. Special attention will then be paid to critical areas in order to avoid reoccurrence of issues.

Obviously these findings need to be communicated and discussed with the turnaround team in time. The QA/QC team must make sure that the corrective actions for the findings of this survey are included as part of the project schedule and coordinate with the project management team for allocating the required resources.

QA/QC during the turnaround

- Define the size of the QA/QC team.
- Proactive culture promotes project quality and progress.
- Understand the role of the QA/QC engineers.
- Well defined communication and reporting matrix.
- React to unexpected scenarios.

The QA/QC team needs to be sized to ensure it can follow all critical activities during the turnaround. Hold and sign off points should never delay the main contractor in achieving progress. The physical arrangement of the different workplaces also has a major impact on the personnel count. The distance between installation, temporary laydown and inspection areas as well as workshops will have a considerable impact and should not be underestimated. Past experience has also shown that customers' own staff with the required experience are often drawn into emergent and 'unplanned' activities and thus suddenly are not available for the intended QA/QC tasks. Thus, sourcing independent QA/QC engineers seems to be a more realistic choice. One QA/QC engineer per two equipment bodies can be used as a rule of thumb.

All involved stakeholders will be in the same boat once the machines are shut down and gas free. It is important that a professional and non-controversial culture is fostered. Although well prepared numerous unpredictable situations will need to be addressed as the projects develop. By experience, proactive QA/QC engineers will contribute not only to the quality but also to the progress of the projects.

Roles and responsibilities need to be clarified and communicated. It is important that the contractor, the project manager and supervisors are aware of the role, responsibility and expectations of the QA/QC engineers. Transparency and periodic meetings contribute to overall progress. These meetings ideally take place at the beginning of every shift, have a clear agenda and should be of short duration only.

The QA/QC engineers are usually equipped with cameras and collect pertinent aspects of the project. Large rotating equipment turnarounds typically involve several multibody trains. Hundreds of important pictures will accumulate within a short time. The clear tagging and structured downloading of the pictures should be clarified ahead of the event to avoid losing control. QA/QC engineers will write reports that provide an overview of observations, highlights and progress. The QA/QC report is not just another version of the service report that should be issued by the contractor. The QA/QC report should provide in depth information on critical areas only. This may be the detailed condition report of a casing that may need to be repaired at the next opportunity. This then helps to prepare the next outage and may place a different emphasis on spare parts and repair strategies going forward.

It is of key importance that the customer, the contractor project management and the QA/QC team work together as an integrated team during the planning phase and throughout the event. Clear responsibilities and communication protocols must be predefined and agreed upon. The contractor and QA/QC, together with the customer, must always be in position to reach critical decisions mutually and on the spot. During a tight project schedule hours count, and the activities cannot be put on hold to wait for decisions that may not be readily made during the night or in a different time zone.

THE ISSUE
Diaphragms layed on the floor require extensive areas for storing

PRODUCTIVITY TOOL
The preparation of special supports/racks for arranging and transporting the diaphragms during the overhaul

THE BENEFIT
Reduced handling risks.
Optimising laydown area.
Saving up to 36 manpower hours

Figure 3. Productivity tools: racks for handling diaphragms.

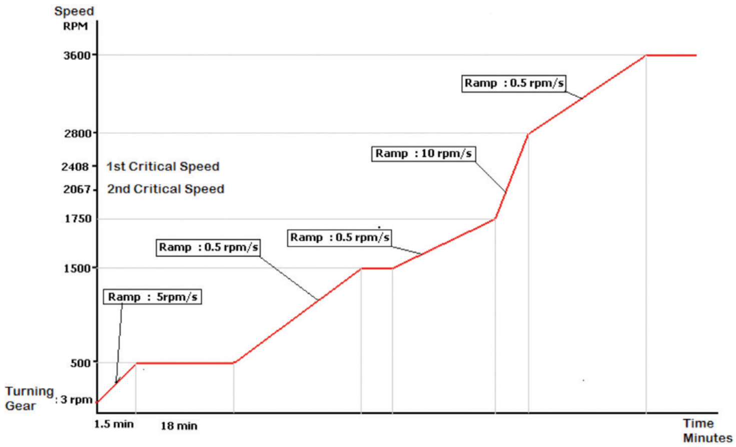

Figure 4. Start up curve prepared for the recommissioning of an overhauled steam turbine.

Recommissioning support

- Prepare recommissioning.
- Observe and consult operations during transient conditions.
- Report findings, review operating procedures.

Following the mechanical completion of a turnaround, the commissioning of the equipment recently overhauled becomes an important task. An inappropriate decision could lead to negating all the work done on a machine. For example, if new inter stage seals were installed during the inspection the machine now runs with tight clearances and the warming process must be closely controlled since any distortion due to improper thermal expansion could lead to internal rubs. Start up rubs leading to heavy vibration could render the expensive renewal of labyrinths useless within seconds.

Intense and long hour activities are inherent to most turnarounds, thus the project team is typically tired but nonetheless still focused on destaffing the project, closing out open items, completing job reports, clarification of commercial aspects or simply cleaning up the working area. Subsequently, little attention is paid to the recommissioning works by the turnaround team; they are mainly owned by the customer's operations team.

With currently prevalent long turnaround windows, recommissioning of a plant is not an activity operations frequently performs. The skill set is impacted similar to that of the maintenance crews as explained earlier. Therefore, independent rotating equipment experts may contribute considerably during the recommissioning and restart phase of the plant. Bad practices may slip in or correct advice is simply not available. The rotating equipment engineer that was involved throughout the turnaround in a QA/QC role is now also familiar with many aspects of the units and is in the meantime also acquainted with the customer's staff. This mix often helps to improve start up practices and helps to avoid problems before they occur or before the machines are exposed to a potentially harmful situation.

Conclusion

Overhauling a large petrochemical plant is a complex undertaking involving many risks that need to be properly addressed and mitigated. Mean time between maintenance is extended, therefore large turnarounds become a rare event for most plants. Aggravating circumstances are retiring workforce, increased number of installations, more challenging HSE requirements, increased quality expectations and last but not least budget constraints.

Investing in competent and experienced QA/QC engineers with dedicated rotating equipment maintenance background will pay dividends by reducing risk to a minimum.

The integrated QA/QC approach that addresses technical and progress items before they become an issue has proven to be a successful model on many large turnarounds. Attention to detail, early planning and thorough preparation are important ingredients. Meeting of minds and awareness of cultural aspects between customer, contractor and QA/QC team are other important aspects that should not be underestimated. To complete large turnarounds safely, with high quality results and in a short time window, a skilled QA/QC team is required that is experienced with anticipating and planning for contingencies. HE