Quality Assurance in Capital Projects

One of the main outcomes of a capital project is the reliability of a new plant, system or equipment. During 20 years of experience working in various capital projects for the mining industry, XPS has investigated failures which have caused significant losses to owners, in many cases amounting to millions of dollars and almost jeopardizing entire projects. Often, failures were related to faulty design, shop fabrication and/or construction. Therefore, significant opportunities exist in the mining industry to improve the success rate of capital projects, improve on-line time at start-up, minimize the occurrence of unplanned maintenance due to equipment failures, and all this with positive contributions to health and safety.

This article is an introduction to Quality Assurance (QA) and presents a few case studies that can be used to describe XPS' QA approach in action during testing and design, fabrication and construction.

What is QA?

Several definitions of quality assurance can be found in the literature. In general, all definitions agree that quality assurance comprises all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service.

This means that quality assurance is not limited to inspections during the fabrication of a product or after a product is delivered to the owner, but it involves activities such as ensuring that the right equipment or product, materials, design, best engineering and fabrication practices are used.

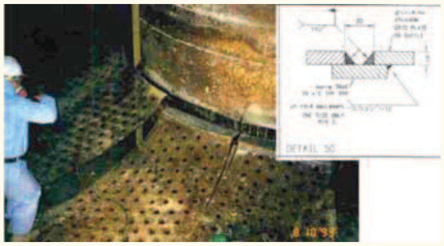
Case Study #1: Materials selection of leaching tanks during the design stage

During the expansion of a zinc leaching operation, new equipment was added to an existing plant to recover precious metals from leaching residues. The most critical part of the expansion was the fabrication and construction of three new leach tanks. The environment consisted of leaching the residue with a solution containing 100g/l H_2SO_4 at 95°C, redox potential = 350mV and maximum chloride content of 50ppm. Another section of the plant had similar leaching tanks operating at approximately 80g/l H_2SO_4 at 90°C. The old tanks were lined with acid resistant masonry and respective membrane. However, the owner requested that the new tanks had to be built using metallic materials only. Corrosion tests of candidate materials were performed with solution from the old tanks with their parameters adjusted to the new conditions. The alloys tested were 904L, 254SMO, Zeron 100, 20Cb3, and Inconel 625. The selection of some of the candidate materials was based on experience in similar environments. Following the corrosion tests, alloy 904L was selected. The QA program for the tanks proceeded with detailed design review, inspections during fabrication and construction. However, the QA program was restricted to the tanks only. Approximately three weeks into commissioning, leaks developed along pipelines, valves and flowmeters, all due to corrosion. The photo (right) illustrates a corroded pipe spool at the tank discharge line. The condition of the tanks became the main concern since failure of the tanks would lead to a major shutdown and re-assessment of the project. Corroded pipe spools, valves and flowmeters were sent to the Materials Technology laboratory of XPS for analysis. The analysis indicated that all corroded components were made of stainless steel type 316 rather than the 904L alloy used for the tank. The tanks were emptied and inspected and no corrosion was found. In conclusion, an adequate QA program was implemented during the tank fabrication but little attention was paid to ancillary equipment. All corroded equipment was replaced with 904L alloy.

Corroded pipe spool from high acid leach tank

Case Study #2: Inspection during construction

A sulfuric SO_2 gas converter from a sulfuric acid plant failed only a few months after it went into service causing a prolonged smelter shutdown. The failure consisted of the collapse of one catalyst bed, consequently causing the converter to lose its functionality. The equipment had to be opened and the catalyst removed to facilitate equipment inspection. Inspection revealed that one of the longitudinal welds connecting two bed segments had failed causing the bed to collapse. Close examination showed that the failed weld was intermittent instead of continuous. However, the construction drawings clearly specified continuous welds and provided clear weld design details. The photo (right) depicts the collapsed bed and the weld design detail from the fabrication drawing. The investigation clearly showed that in this case the material selection, design and specifications were all properly done. However, the project lacked proper surveillance during construction. The lesson learned here is that the QA cycle has to be complete, from the initial project development to execution. The exclusion of one QA step can lead to costly consequences.

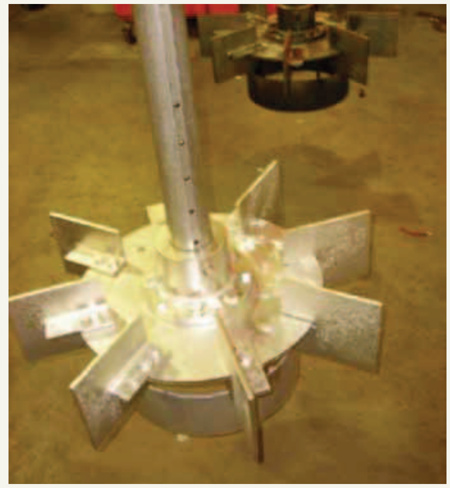


Catalyst bed failure

Case Study #3: Materials selection during pilot testing and design

During the development of a new hydrometallurgical process for precious metal recovery, questions were raised regarding the compatibility of various materials of construction with the process. This is not uncommon in the development stage of any new process particularly when process conditions are outside existing operations experience. In this case, the high pressure acid leaching (HPAL) was performed in batches with acid concentration, redox potential and chloride concentration of the solution dittering considerably from other HPAL operation with acid concentrations higher than 250mg/l. Initially, candidate metallic materials were tested in pilot plant autoclaves which closely simulated the process conditions, including solution chemistry, temperature and pressure. During these tests, it was concluded that some candidate alloys had acceptable corrosion resistance for ancillary equipment such as valves, agitators and spargers, however, they were not suitable for the shell fabrication, due to requirements for pressure containment and overall autoclave performance. An alloy test program was initiated and served to support ancillary equipment selection. During the testing, a decision was made to include acid resistant masonry and mortars in the program and to consider the feasibility of designing the autoclave shell with masonry lined carbon steel complete with membrane materials. Finding the proper acid resistant brick, mortar and membrane materials was very challenging due to the high acid concentrations. Tests were performed in autoclaves and specimens were exposed to both the vapor and liquid zones of the pilot autoclave. Following the autoclave tests, all specimens were submitted to SEM and chemical analysis as well as mechanical testing. The test duration was approximately two months and cost approximately $150K CAD. The final material selection for the autoclave lining was based on the tests results and the total cost of the plant was $60M CAD. During the plant commissioning only minor problems were found at the autoclave cover seal. This was rapidly overcome and no other major problems were observed.

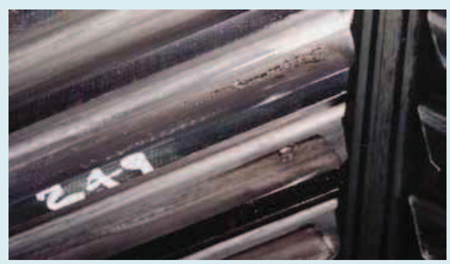
Autoclave shell



Mixer and shaft

Case Study #4: Inspection during gear fabrication

After the failure of a hoist bull gear from an underground mine, a new fabricated gear was installed and started to develop progressive pits on its teeth face immediately after it went into service. The photo (right) depicts the details of progressive pitting on one tooth of the newly installed gear. Only the original drawing and performance parameters had been used as procurement documents. Therefore, no quality assurance dossier was delivered with the gear. The gear hub and spokes were made of welded carbon steel while the rim was made of quenched and tempered low alloy steel and welded onto the spokes. The gear supplier initially suggested that the pitting was due to normal run in. However, the owner and the supplier decided to perform weekly inspections to assess the progression of the pitting damage. After three months in operation it was concluded that the pits were in fact progressive pitting, which could lead the gear to catastrophic failure. Nothing had been changed in the mine regarding the hoist loading and speed as well as the lubrication system. The gear had also been replaced in kind with exactly the same dimensions as the original one. Close examination revealed that the pitting damage followed a pattern, being very pronounced every sixth tooth. Therefore, there was evidence of potential dimensional errors on the gear which had most likely originated during the gear fabrication. A detailed dimensional inspection was then performed on site and the results indicated that some teeth were thicker than others. Furthermore, the thicker teeth followed a pattern of every sixth tooth, consistent with the pitting pattern. The supplier then proceeded to inspect its own gear cutting equipment and the defective teeth were traced back to off-spec cutting tools. Another gear had to be fabricated to replace the defective one. The lesson learned here is that a proper QA procedure, which included dimensional checks of the fabricated gear, would have prevented the failure. Since then, a detailed specification has been used for the procurement of bull gears, which amongst other things has requirements for inspection and testing plans, including detailed dimensional inspections at the fabrication shop.



Progressive pitting damage on gear tooth face

For XPS Materials Technology support QA during testing, design, fabrication, construction.
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