PIPING REPLACEMENT TO ASME-B31.3 IN THE WATER INDUSTRY? WHY NOT?

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ABSTRACT

Following a catastrophic piping failure - where the plant roof of Tauranga City Council's Oropi Rd Water Treatment Plant was severely damaged - Harrison Grierson was commissioned to design and project manage the upgrade for the Clean in Place (CIP) pipework. In addition to the pipe failure there were also several chemical solution leaks in the network requiring a complete pipe network replacement. Our brief was to design and replace the leaking and defective pipework without affecting plant operations, limiting the construction period to CIP downtime cycles.

A complex element to be factored into the design was the use of highly corrosive chemicals, including heated acids, which are periodically carried in the CIP piping network. This had a significant impact on the project management, risk management and Health and Safety considerations associated with the design and construction of the upgrade. This meant that the construction methodology had to become an integral part of the design to achieve the objective of implementing the design solution under a fully operational plant.

As part of the upgrade Harrison Grierson also completed tender specifications, contractor selection, quality inspections, Safety in Design (SiD) and HAZOP workshops.

The project came in under budget and was delivered ahead of schedule.

This paper will discuss how this outcome was achieved through effective project management and contractor selection, and the adoption of an unconventional design procurement approach.

KEYWORDS

Pipeline Design, Safety in Design, Project Management, Tenderer Selection, Contract Management, Contract Execution

1 INTRODUCTION

A Clean in Place (CIP) pump discharge pipe at Tauranga City Council's Oropi Road Water Treatment Plant (WTP) failed catastrophically, which severely damaged the plant roof. Luckily no plant operator was in the plant room when the event occurred. The remaining piping network at the plant was also in a poor condition, with CIP solution leakages occurring throughout the network. As a result Tauranga City Council (TCC) commissioned Harrison Grierson to design the upgrade for the CIP pipework, tender and project manage the contract and act in the role of Engineer to Contract.

The CIP piping network is essential for the operation of the WTP membrane units and thus the overall plant operation. This network carries the chemicals required for the periodic cleaning of the membrane cells. The chemicals used for the cleaning process are highly corrosive and can include heated acids.

The upgrade at the Oropi Road WTP involved replacing the existing Acrylonitrile Butadiene Styrene (ABS plastic) CIP piping network. The upgrade had to be completed without affecting plant operations, limiting construction periods to CIP downtime cycles.

This paper describes how this project was successfully implemented using a novel approach in the water industry.

2 A NOVEL DESIGN APPROACH IN THE WATER INDUSTRY

The design of the piping network replacement was based around Council's requirement to complete the upgrade without affecting WTP operation.

Limiting the construction periods to CIP downtime cycles meant the design had to take into account the construction methodology in a far more involved way than what is typically expected on similar projects.

Appropriate pipe material selection, suitable supporting arrangements, SiD considerations and a construction methodology compatible with operations were the key technical challenges that had to be considered.

For this project we embraced Safety in Design and used it as a tool to produce the best outcomes for our client. Using our SiD process contributed to the selection of stainless steel as the preferred pipe material, instead of replacing the pipework like for like. This led to the use of the design and installation standard ASME B31.3 Process Piping, commonly used in the power industry was used in this project.

This benefitted the project in the following ways:

- The selected pipe material was corrosion resistant to applied chemicals
- Easy pre-fabrication of pipe spools in workshop to cater for site assembly
- Welded pipe joints could be positively tested via non-destructive testing (NDT) and pressure testing in a controlled workshop environment, instead of on site
- The applied piping standard only required the pipework being tested on site with a non-pressurised CIP solution, reducing site pressure hazards and reducing construction time.

To be able to control installation quality and processes, we applied a well-known design and installation standard ASME B31.3 – Process Piping. This rigorous design standard is generally used in the power industry. This not only attracted higher quality contractors, but also meant that a greater proportion of the pipework fabrication and testing could be done off site.

This design and installation standard outlines a rigorous approach to pressure piping design, material selection and support design, as well as fabrication, assembly and erection. NDT methods are outlined in great detail, requiring an in-depth knowledge of this standard.

While good engineering practice is used for pipework and equipment design in the water industry, we used a very prescriptive design and installation standard to have full control of all quality parameters during the design and the construction project phase. Using ASME B31.3 set the landscape for a successful project implementation.

3 SO WHAT ARE THE BENEFITS USING ASME B31.3?

During concept design we focused extensively on the pipework arrangement design. This had to be considered in detail as it influenced the construction methodology and set the path for a successful project.

Early in this phase it became apparent that applying good engineering practise only in the piping network replacement would not be sufficient. To have full control over detailed design, fabrication and installation quality, as well as NDT of the fabrication, we applied ASME B31.3.

The relevant standard clauses could be utilized to the projects advantage:

Clause 304.1.2 – Straight pipe under internal pressure: The minimum pipework design wall thickness is calculated here, which included the provision of a corrosion allowance to ensure a 25 year plant service life. During the construction period the decision was made to change the CIP chemicals. During this modification of the design criteria, the pressure rating of the pipework had to be re-rated, without impacting the Contractors brief and construction cost.

Clauses 344 & 345 Types of examination & Testing: These clauses cover all pipework examination and testing requirements. All NDT could be carried out off-site on the Contractor’s premises, including radiography to Clause 344.5 of all butt welds, the most critical pipework welds as well as hydrostatic leak testing to Clause 345.4.

Clause 345.1 – Required leak test: Having conducted all relevant NDT off-site, only an in-service leak test needed to be carried out on site. This is allowed for at the Owner’s discretion.

Applying these clauses not only removed the site pressure and radiography hazards, but also saved valuable construction time.

To make full use of this standard a comprehensive stainless steel pipework specification was project specifically created, which included detailed fitting material, dimensional specifications and corrosion allowances. This plant standard is generally not used in the water industry and is usually applied in the power industry. Our ability to apply this standard effectively helped reduce the necessary construction time.

4 PROJECT COMPLEXITIES AND DESIGN CHALLENGES

4.1 COMPLEXITY AND DESIGN CHALLENGES

The design and installation of the replacement pipe network was of a complex and challenging nature. Key factors that added to the complexity of the project included:

1. Installation time constraints: The design needed to consider maintaining full plant operation during the installation of the replacement pipework. Pipework installation was constrained around short CIP cycles, as short as three days.

2. Physical installation constraints: The existing water, dosing and service air infrastructure at the WTP imposed a very confined installation space, which needed to be considered during detailed design.

3. Hazardous environment: The use of hazardous CIP chemicals, ie. sodium hydroxide, hydrogen peroxide and sulphuric acid, made the material selection, pressure relief and pipe pressure rating calculations challenging. The applied chemicals and the confined space during the installation process needed to be considered. These

hazardous environmental conditions during the project implementation phase required a high focus on Safety in Design for the project.

The overall effect these factors had on the design and outcomes of the project are discussed below.

4.1.1 INSTALLATION TIME CONSTRAINTS

The need to maintain plant operation during the upgrade installation was apparent early in the project. This key client objective influenced the design and project management of the upgrade.

As a result, installation was restricted to CIP downtime cycles. This required the need for a quick construction and installation beyond the usual cost motivated incentives, and meant the construction methodology was an integral part of the design.

The pipe material selected for the design was the essential part of overcoming this challenge. The use of stainless steel leant itself best for prefabrication and site assembly. ASME B31.3 – Process Piping was used during the detailed design phase and to control pre-fabrication and site installation of the piping design.

4.1.2 PHYSICAL INSTALLATION CONSTRAINTS

The design of the upgrade was physically constrained by the tight arrangement of all remaining pipework at the WTP. The existing pipework could not be removed to aid demolition and re-assembly. Replacing the pipework like for like with ABS pipework would have required all pipe elbows to be installed in-situ. This would have led to increased construction time on site, exceeding the allowable time between CIP cycles. Most of the pipework was also located in a trench classified as a confined space, adding to the installation constraints.

Specifying stainless steel pipe and short radius elbows using dimensional pipework specification ASME B16.9 overcame this challenge to assemble the pre-fabricated pipework in one piece and reduce the on-site assembly time in a confined space to a minimum. A comprehensive pipe specification outlining fitting dimensions and material specification was part of the detailed design.

4.1.3 HAZARDOUS ENVIRONMENT

To identify and eliminate hazards early on in the design process, Safety in Design was used to address each design element throughout its project life cycle. This included considering Health and Safety elements associated with the construction, commissioning, operation, maintenance and demolition of the asset.

SiD was a major driver in the decision to use stainless steel instead of ABS pipework. Confined space installation in the existing pipe trenches was identified as one of the major site hazards. While we could not design out this hazard in its entirety, using stainless steel allowed us to design to standard ASME B31.3 and reduce onsite assembly and testing requirements to a minimum. The durability of this material also limited the future maintenance requirements of the system, adding to the long term safety benefits of the design.

This proved to be an effective risk management strategy and also resulted in significant cost savings to the client in the form of reduced construction time.

5 PROCUREMENT CONSIDERATIONS

CONSULTANT SELECTION

Generally consultant selection for this type of project would be carried out via an Expression of Interest or Request for Proposal process. This would have added to the construction timeframe and project budget.

TCC has single sourced the design, tender specification and contract observation component and involved us early on in the concept design stage. This helped form the project scope to the most cost-effective design and delivery method for the client.

CONTRACT PROCUREMENT

The Price Quality Method was used as procurement tendering strategy, with a high weighting of 60% on quality, proven track record and capability. This practice is not commonly adopted in the water industry, which typically favours lowest conforming price as the main factor contributing to tenderer selection. As a result of taking a more innovative approach to procurement, the highest quality tenderer with the most relevant track record was selected.

Selecting a high quality contractor was a key factor in success of the construction phase of the project. Construction was severely constrained during this project due to the requirement of maintaining plant operation. This tender method attracted higher quality contractors.

This approach combined with a measured value contract with agreed unit rates achieved the best value for the client. A detailed bill of quantity was provided to the tenderers. Unit material and installation rates were in turn provided by the tenderers. This approach provided increased certainty on variation rates, should the client decide to increase the scope of works at a later stage.

The ultimate project cost was delivered below budget and ahead of schedule.

6 PROJECT COLLABORATION

Using a highly collaborative approach also meant the construction methodology could be adapted quickly to accommodate all construction constraints. This ultimately made the construction process easier and more efficient.

Client and operator input were also an important part of the design and construction process. Interface challenges could be easily resolved and project decisions could be fast-tracked. This is illustrated below:

- Site kick-off meeting and contractor factory inspections were attended by the end client and communicated to the designer via Harrison Grierson’s quality control report.

- The client, operations staff, designer & contractor jointly undertook a HAZOP and SiD workshop. The HAZOP portion was facilitated by a trained HG facilitator remotely. For the SiD portion the lead designer had been on site, running this session.

- Some intermediate inspection could be carried out by the client, resulting in project savings. TCC inspection details were captured with our quality inspection template, ensuring seamless communication with all stakeholders.

Having a close working relationship established with both the Contractor and the Client made it easy to get buy-in on the construction methodology.

This collaborative approach encouraged by our project and design management also effectively resolved potential interface challenges.

7 CONCLUSION

Selecting a high quality contractor, applying a highly collaborative project approach and using an innovative design approach to a pipework replacement delivered a high quality project outcome. It also resulted in the project coming in under budget and ahead of schedule.