Shire of Merredin

Merredin Water Tank
Inspection Findings

June 2019

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 General

Shire of Merredin has engaged GHD Pty Ltd (GHD) to conduct a visual inspection and overall structural integrity assessment of the Merredin Water Tank located at Merredin, Western Australia. This report provides a summary of the site inspection findings of the proposed heritage water tank.

1.2 Purpose of this report

The purpose of this report is to present the results of site inspection findings and overall structural integrity assessment of the 25000 gallon WAGR cast iron water tank at Merredin.

The assessment is based on a close visual inspection from inside the tank which was conducted on 11 June 2019 by GHD Senior Materials and Corrosion Engineer.

1.3 Scope and limitations

The scope of work comprises the visual inspection and overall structural integrity assessment of a 25000 gallon WAGR cast iron tank at Merredin. The aim was to understand the level of deterioration and provide suggestions to improve the structural integrity of the proposed cast iron tank and safety. This report has been prepared by GHD for Shire of Merredin and may only be used and relied on by Shire of Merredin for the purpose agreed between GHD and the Shire of Merredin as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Shire of Merredin arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4. of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Shire of Merredin and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

1.4 Assumptions

GHD assumes all information, data and statements provided by the Shire of Merredin during this assessment are accurate and complete. We have not sought to independently verify such information other than through our own analysis. GHD assumes that they have been provided access to all relevant and available resources to fulfil the scope of work.

1.5 Reference Drawings

The following information provided by the Shire of Merredin for the purpose of this study:

- Standard WAGR drawing, 25,000 gallon engine water tank, EEL Plan No. 2873/31.
- Standard WAGR drawing, 50 foot tank stand for 25,000 gallon tank, EEL Plan No. 12763, 1911.

The above listed drawings are provided in Appendix A.

1.6 Tank Construction

- Wall: Vertically bolt connected cast iron panels with carbon steel packer plate at joint connections;
- Base/wall: Bolted curve cast iron corners;
- Base : Cast iron panels connected by bolts and infill concrete top, approximately 100 mm;
- Timber bearers at regular spacing to support the base panels;
- Diagonal internal tie rods connected to wall and floor panels;
- Stainless steel ties attached to top of the panel as restraint (recently installed); and
- Tank stand consists of:
- Timber columns
- Concrete strip footing
- Horizontal and diagonal timber bracing.

2. Inspection Methodology

For this assessment the following activities were completed:

2.1 Desktop Review

The existing drawings of the tank were reviewed to understand the construction materials, dimensions and critical load focus areas of the proposed tank.

2.2 Visual Inspection

A direct visual inspection was completed over the accessible areas from inside of the tank. The tank internal surface was accessed through the temporary scaffolding established around the tank provided by the Shire of Merredin contractor. The exterior surface of the tank was visually inspected from the scaffolding. The tank stand was also visually inspected from ground level.

2.3 In-situ Hardness Testing

In situ hardness testing was completed on the representative locations on the tank wall panels. The rough surface of the cast iron panels due to corrosion gave inconsistent readings at site. A broken off sample of the damaged cast iron panel was collected for completing the hardness testing after polishing the surface at the office laboratory.

2.4 Photograph

The current condition of the tank was broadly photographed to allow remote visual assessment of structural elements in consultation with GHD Principal Structural Engineer. The site photos are shown in Appendix B.

3. Site Inspection Findings

The following sections summarise the consultations, observations, analysis and evaluation of the tank reviewed.

3.1 Close Visual Inspection

3.1.1 Internal Surface of Tank

The internal surface of the tank was visually inspected. The summary of findings are outlined below:

- Vertical and diagonal cracks were observed on four cast iron panels at the south and east sides of the tank's wall. Refer to Figure 1 below for an example of this. This failure mode may be due to compression and tension forces caused by thermal stress on the empty tank acting along the wall and the restraint offered by corner resulting in a longitudinal crack. Once a crack has initiated, it may travel along the width of the panel. In some instances cracks have formed on corner sides of the cast iron panels near the bolt joint connections.

Figure 1 Vertical and diagonal cracks

- The majority of the bolt connections were failed as a result of cracking developed around the bolt joints as shown typically in Figure 2. The majority of the bolts were still held in place due to heavy rust formation around the bolts and the bolt holes.

Figure 2 Cracks around bolt connections

- The interior surface of the tank were significantly rusted due to exposure to wet atmosphere.
- The carbon steel packer plates between the cast iron panels at joints were heavily corroded. The expansion due to rust formation of packer plates caused enough stress to create cracks within the adjacent cast iron panels. A typical photo is shown in Figure 3.
- Three out of the four tank corners were in a very poor condition. Visible cracks were observed on all joint connections at corners. A loose visible piece of cast iron was observed on the south east side corner of the tank. The separated piece is potentially a safety issue due to possibility of falling due to current instability.
- The cast iron pipe extended from the bottom of the tank to ground level was entirely separated in one location close to the bottom side of the tank. This has caused by circumferential cracking as shown in Figure 4. Circumferential cracking is the most common failure mode for small diameter (<380 mm diameter) gray cast iron pipes. Typically this type of failure is caused by bending forces applied to the pipe. The resulting failure occurs in a manner similar to a twig snapping, with the failure crack propagating across the circumference of the pipe. This type of failure could also be caused by soil movements producing tensile forces on the pipe, producing a simple tensile failure. However no sign of soil movement was observed on the site around the tank stand foundation and pipe support.

Figure 3 Packer plate expansion due to corrosion

Figure 4 Circumferential crack on the cast iron pipe

- The tie rod connection cleats were heavily corroded (dysfunctional). A typical photo is shown in Figure 5.
- The floor cast iron panels were covered by concrete. Longitudinal cracks were observed on the floor panels where the concrete layer was removed.

Figure 5 Heavy corroded tie rod connection cleats

Figure 6 Crack on the floor panel of the tank

3.1.2 External Surface of Tank

The external surface of the tank was visually inspected from the scaffolding. The summary of observations are listed below:

- Cracks were observed on several location at the bottom corners

Figure 7 Cracks on the bottom joint panel

- The majority of joint connections and the interface between the tank bottom corners and timber beams were heavily corroded as shown typically in Figure 8.

Figure 8 Significant rust on the interface between the tank bottom corner and timber beam

3.1.3 Tank Stand

The tank stand was visually inspected from the ground level. The timber columns and cross bracings elements were reasonably in good condition with some missing bolts in joint connections. The timber columns were slightly deteriorated due to age and weathering. Weathering (wetting/drying) results in the creation of cracks but not splits the wood. The timber elements were structurally functional with no visible sign of biological attack (fungi and termites), fire and impact damage. No sign of movement or distortion were observed on the timber column foundation. A typical photos of tank stand and foundation are shown in Figure 9 and 10.

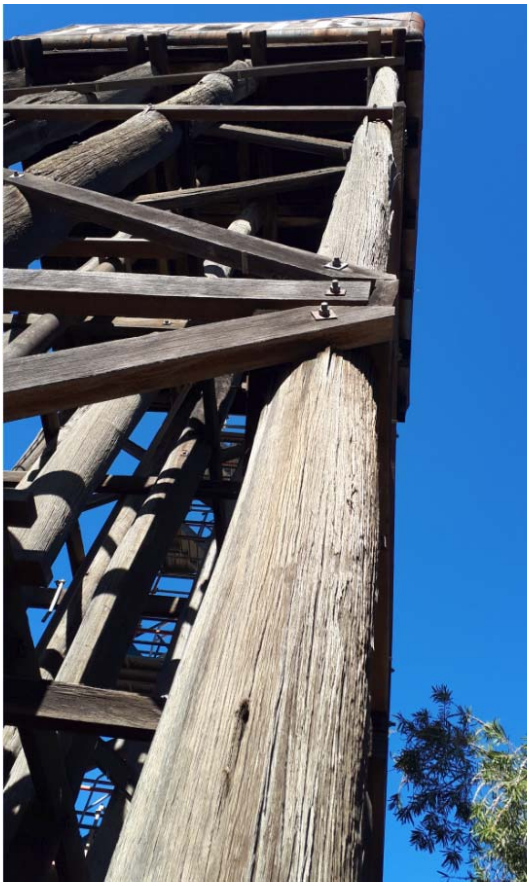


Figure 9 Tank Timber Columns

Figure 10 Tank foundation

3.2 Hardness Testing

A sample of the cast iron plate was collected from the site for hardness testing. The result of hardness reading are summarised in Table 1.

Table 1 Hardness Testing

Reading	Hardness (HRC)
1	20
2	22
3	22

The results indicate the cast iron materials are most likely Gray Cast Iron, ASTM A 48 Class 40.

4. Cause of Damage

The tank was kept empty for a significant period and has been continually subject to compression/tension stress caused by temperature fluctuation and flexural load caused by wind.

Furthermore the expansion forces caused by corrosion of packer plate i.e. up to six times of the original thickness, in turn creates cracks over time. As a summary, the root cause of damage is most likely due to:

- Corrosion of wall panel joint carbon steel packer plates and subsequent expansion; and
- Excessive forces caused by environmental impact (wind and temperature).

Any repairs should be accompanied by an evaluation of the mode of failure of the material to enable the repair to mitigate future failure, which may include modification of the element or strengthening.

5. Structural Integrity Assessment

5.1 Structural Integrity

Due to the advanced nature of the tank wall and floor panels cracking and bolt joint connection deterioration and failure, the tank is considered to be structurally unstable and there is a risk of sudden failure, which can result in injuries or severe damage.

5.2 Feasibility of welding repairs

Cracked or fractured metals can be repaired by welding however due to poor weldability of the proposed cast iron (i.e. hardness > 20HRC), repairing by welding is very difficult and costly. This is largely due to the brittleness of the material. The heat generated during welding creates localised stress to develop in the material which because of the brittleness of the cast iron can only be relieved through cracking of the material. This can be prevented through high temperature preheat however this is very difficult to control and hence is often impractical on site.

5.3 Feasibility of cold metal stitching repairs

Another alternative to welding is through cold metal stitching. The stitching process entails drilled holes on the material in a line across the crack and also perpendicular to the crack, then using stud screws overlap on each other to completely fill the crack. However, this repair method is suitable when the parts are not entirely separated by the cracks e.g. the cracks have not developed to the extent that split the element. However the majority of joint connections and panels were already separated and it is too late to repair the cracks by cold metal stitch repairing method.

6. Recommendation

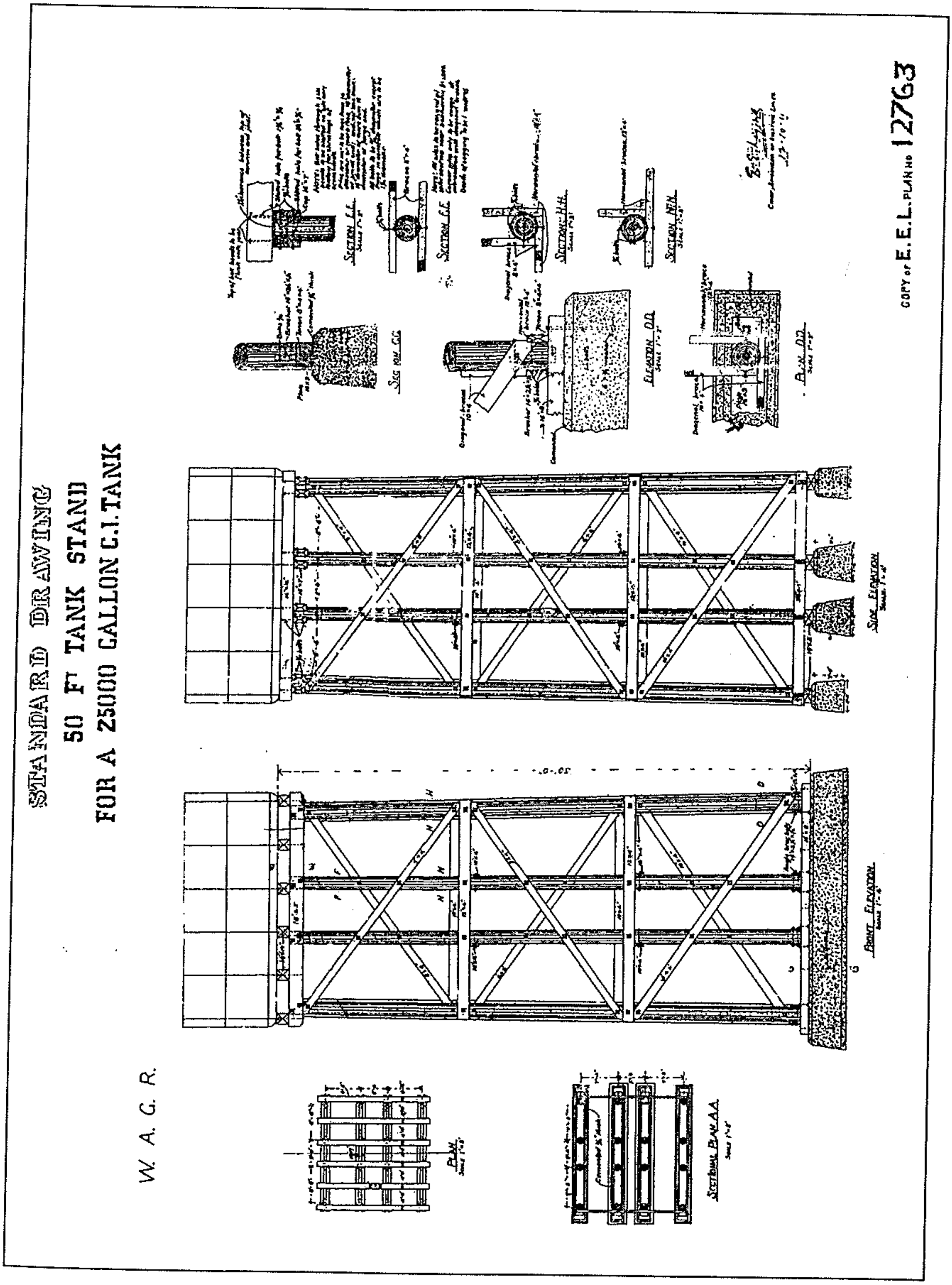
It is considered impractical to reinforce the tank wall and floor due to the material properties (brittleness) and existing cracked panels.

By considering above and with respect to potential safety issues due to poor structural integrity of the cast iron tank, it is recommended to demolish the tank.

Appendices

Appendix A – Tank Construction Drawings

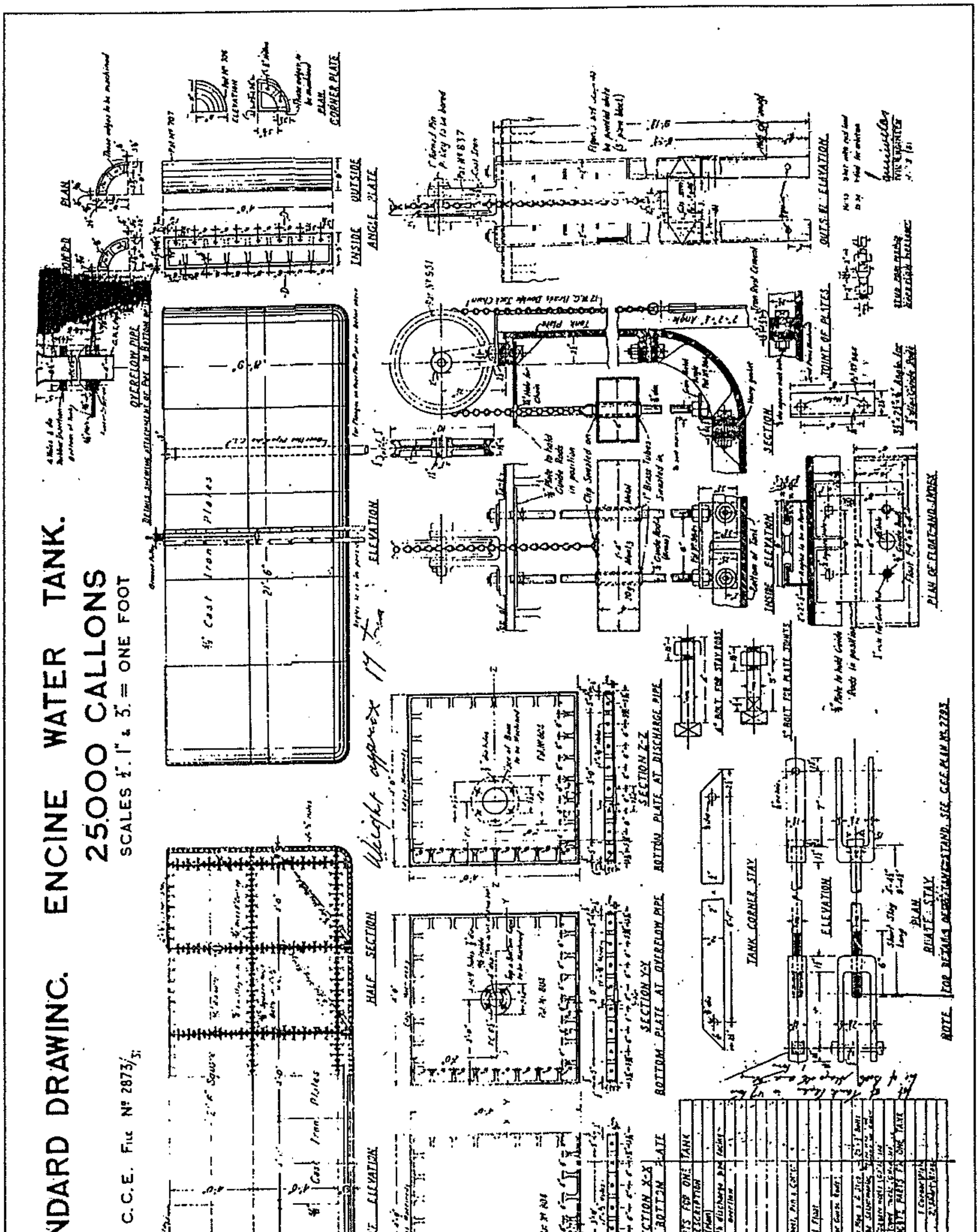
- Standard WAGR drawing, 25,000 gallon engine water tank, EEL Plan No. 2873/31.
- Standard WAGR drawing, 50 foot tank stand for 25,000 gallon tank, EEL Plan No. 12763, 1911.



Standard WAGR drawing, 50 foot tank stand for 25,000 gallon tank, EEL Plan No. 12763, 1911.

PLAN 10 Water tower and tank

Tower: Plan EEL No 12763, 1911.



Standard WAGR drawing, 25,000 gallon engine water tank, EEL Plan No. 2873/31.

PLAN 11 Water tower and tank

Tank: Plan EEL No 2873/31.

Appendix B – Photos

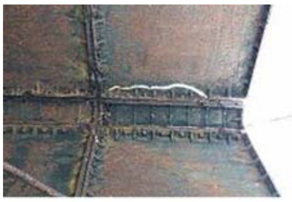

20190611_111613


20190611_111658


20190611_111701


20190611_111704


20190611_111708


20190611_112253

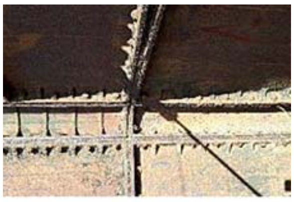

20190611_112510


20190611_112525


20190611_112631


20190611_112632


20190611_112756


20190611_112830


20190611_112907


20190611_112909(0)


20190611_112909

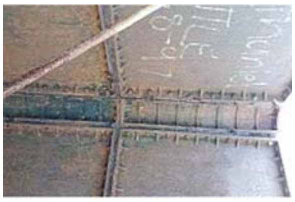

20190611_112911

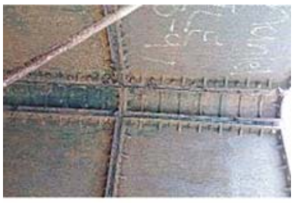

20190611_112918


20190611_112926


20190611_112929


20190611_112931


20190611_112948(0)


20190611_112948


20190611_113116


20190611_113117


20190611_113223


20190611_113345


20190611_113520


20190611_113701


20190611_113928


20190611_114059


20190611_114316


20190611_114624


20190611_115425


20190611_105408


20190611_105501


20190611_105540


20190611_105600


20190611_105611


20190611_105622


20190611_105624


20190611_105714


20190611_105822


20190611_105837


20190611_105839

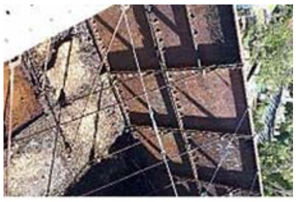

20190611_110234


20190611_110243

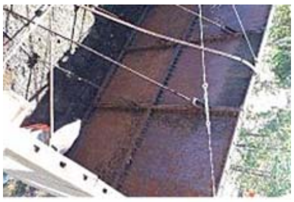

20190611_110247


20190611_110408

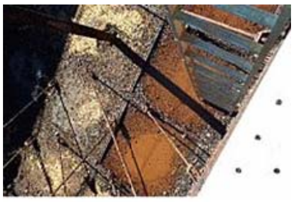

20190611_110549


20190611_110553


20190611_110556


20190611_110601

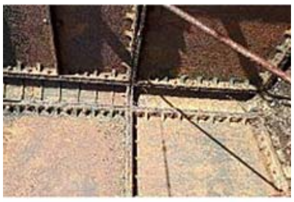

20190611_110607


20190611_110610


20190611_111423


20190611_111424


20190611_111502


20190611_111603

GHD

Level 10
999 Hay Street
T: 61 8 6222 8222   F: 61 8 6222 8555   E: permail@ghd.com

GHDDocId/Document12

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	V Afshari	P Tonkin		P Tonkin		18/6/19

www.ghd.com