RAIL SAFETY INVESTIGATION REPORT

STRUCTURAL FAILURE OF A SQDY WAGON

GULGONG

5 DECEMBER 2012
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THE OFFICE OF TRANSPORT SAFETY INVESTIGATIONS

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### ACRONYMS AND ABBREVIATIONS

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<td>Country Regional Network</td>
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<td>DIP</td>
<td>Directly Involved Party</td>
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<td>Independent Transport Safety Regulator</td>
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<td>JHR</td>
<td>John Holland Rail</td>
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EXECUTIVE SUMMARY

At 0325 on 5 December 2012 at Gulgong in NSW a train crew conducting a roll by inspection noticed that a wagon had sagged in the middle and was almost dragging on the ground. The wagon was one of a fleet of 100 ‘skeletal’ type container wagons belonging to QUBE Logistics (Rail) Pty Ltd (QUBE), all of which had entered service within the previous 12 months.

The immediate cause of the wagon sagging was the failure of a weld that ran transversely across the centre of the underside of the wagon’s main structural beam. The bending forces applied to the welded joint then transferred to the side members (sills) which gradually split, from the location of the failed welded joint, upwards to the top member of the beam.

A second wagon on the same train was found to have welding defects in the same joint as the failed wagon. Both welds were performed by the same welder on consecutive days. Inspections during manufacture, including ultrasonic testing in the case of the joint that failed, did not identify any defects, nor did visual inspections carried out during routine maintenance after the wagons entered service.

The investigation found that the wagon manufacturer, located in the United States of America, used a welded joint that may not have complied with relevant Australian Standards. Also, the manufacturer did not provide accurate instructions for performing the weld to its welding personnel; did not have complete records in relation to welder experience and qualifications; and did not detect flaws present in the failed wagon, or some other wagons, through testing or inspection during the manufacturing process.

It is recommended that QUBE conducts independent in-service stress testing of sample SQDY wagons and that the Office of the National Rail Safety Regulator require that QUBE has appropriately certified the SQDY wagon design. In addition, it is recommended that the manufacturer reviews its record keeping, testing, inspection and quality systems. The manufacturer should also ensure that products supplied to the Australian market comply with Australian Standards.

The full details of Findings and Recommendations of this rail safety investigation are contained in Parts 3 and 4 respectively.
PART 1 FACTUAL INFORMATION

Preamble

1.1 QUBE Logistics (Rail) Pty Ltd (QUBE) containerised grain train 8448N originated at Gilgandra on Tuesday 4 December 2012. The train was destined for Walsh Point in Newcastle (see Figure 1).

1.2 The train consisted of 35 SQDY container carrying wagons hauled by two locomotives. The train had a total trailing mass of 1958 t and a total length of 554.5 m. Each wagon carried two 20 ft (6.096 m) containers used to carry grain. While the containers on the first 13 wagons were empty, the remainder were each loaded with 27 t of grain. The train had departed Gilgandra with only 22 wagons loaded with grain due to time constraints.

1.3 The train crew visually inspected the train prior to departure with no faults being recorded then or on its journey to Gulgong.

1.4 After departure from Gilgandra the train ran without incident, passing from the John Holland Rail (JHR) Country Regional Network onto the Australian Rail Track Corporation (ARTC) Network at Troy Junction (Dubbo) and so through...
Merrygoen to Gulgong. On arrival at Gulgong a crew change occurred. The fresh crew took charge of the train and commenced departure at about 0325.¹

The Incident

The crew that had been relieved, as is usual practice, performed a ‘roll by’ inspection from a position adjacent to Station Street level crossing as the train departed. As the 20th wagon passed (SQDY 00060G), it was observed to be sagging in the middle. Using their hand held radio, they alerted the train crew to the problem and the train was immediately brought to a stand.

¹ All times referred to in this report are in Eastern Daylight-saving Time (UTC+11 hours).
1.5 The welded joint located in the centre of the bottom plates of the main structural beam of the wagon had failed. As the failed joint and surrounding material ‘worked’\(^2\) during the journey, the cracks initiated at the failed weld propagated vertically upwards, eventually reaching the top member (see Photograph 1).

1.6 As the wagon sagged due to the weight of the load and in-train forces, the tops of the containers came together so providing support and preventing it sagging further. The bottom of the middle of the wagon was just above the top of the sleepers (see Photograph 2). In this state, the wagon struck some items of infrastructure such as level crossings that had a profile above sleeper level.

Photograph 2: Failed wagon at Gulgong

Incident Response

1.7 The crew notified ARTC Network Control at Broadmeadow of the incident and local infrastructure maintenance personnel were directed to attend. The local Police were also requested to attend to control road traffic as the train had come to a stand just clear of the Station Street level crossing but close enough for the warning lights to remain activated.

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\(^2\) ‘Worked’: repeatedly bent one way then the other.
1.8 Both OTSI and Independent Transport Safety Regulator (ITSR)\(^3\) investigators attended the incident site at Gulgong, as did QUBE’s National Safety Manager. The Director of Australian Operations of the National Railway Equipment Co., being the representative of the manufacturer, American Railcar Industries Inc. (ARI), also attended. All 35 wagons making up the train were visually inspected with ten being found, by the manufacturer’s representatives, to have potential defects in the same welded joint that had failed in SQDY 00060G. One wagon, SQDY 00065F, was declared unfit to travel in a loaded condition due to the severity of the defect observed. The wagon had its containers removed prior to being transferred to Pacific Rail Engineering’s (PRE) yard in Newcastle for further inspection.

1.9 ITSR issued a Prohibition Notice to QUBE, dated 5 December 2012, to prevent this class of wagon from being used until suitable inspections had been completed and repairs made as required.

1.10 Before allowing rail traffic to use the line, ARTC conducted an inspection by road-rail vehicle between Gulgong and the interface with the Country Regional Network, controlled by JHR, approximately 180 km away near Dubbo.

1.11 At approximately 1700, the local ARTC Infrastructure Manager called his opposite number in JHR and informed him of the incident. JHR Network Control was notified of the incident by QUBE at 1820 along with the advice that SQDY wagons were to be suspended from service.

1.12 Since train 8448N had passed, no rail traffic had run over JHR’s Gilgandra - Troy Junction section. As a precaution, when a track machine ran over the line the following day, its operator was asked to check for any damage. None was reported.

**Infrastructure Damage**

1.13 In addition to the damage to wagon SQDY 00060G, the passage of the wagon had damaged the road surface on a number of level crossings (see

\(^3\) On 20 January 2013 ITSR formed the NSW Branch of the Office of the National Rail Safety Regulator.
Photograph 3) and cattle grids en route, and damaged the points leading to the loop at Gulgong. The first damaged infrastructure was located at 365.900 km, some 25 km prior to Gulgong.

Photograph 3: Level crossing damage

Wagon Manufacturer

1.14 ARI was formed in 1994 but can trace its roots back to the Milton Car Works founded in Pennsylvania in 1864. The organisation is a major participant in the design and manufacture of railway rolling stock. ARI also provides maintenance facilities, engineering services and fleet management in the USA. Today ARI has manufacturing facilities for rolling stock at two locations, Marmaduke and Paragould, both in Arkansas. The SQDY wagons were produced at the Marmaduke facility.

Wagon Information and Loading

1.15 The wagon type was designated as ‘SQDY’. They were 40 ft container wagons designed to carry a single 40 ft (12.192 m) or two 20 ft (6.096 m) containers. The failed wagon was SQDY 00060G, being one of a fleet of 100. All had entered service with QUBE within the previous 12 months.

According to the consist supplied by QUBE, wagon SQDY 00060G had a gross mass of about 76 t at the time of the incident, being loaded with two 20 ft containers filled with grain. The mass was verified by weighing the containers as they were removed from the wagon. The wagon was about 16 t below its maximum permissible mass.
PART 2 ANALYSIS

Design of SQDY Wagons

2.1 The SQDY wagons were 40 ft container wagons specifically designed for QUBE to carry a single 40 ft (12.192 m) or two 20 ft (6.096 m) containers. They had a total length of 14.7 m and a mass of 15.9 t empty with a maximum permissible mass of 92 t and a maximum operating speed of 100 km/h. The wagon was designed to have a 5,000,000 km service life, which is estimated to represent a span of about 20 years.

2.2 The wagon was designed by ARI who stated that the wagons were designed to American Association of Railroads (AAR) and American Welding Society (AWS) D15.1 standards as well as current Australian standards. This was supported by QUBE’s pre-order audit of ARI which identified that the wagons would comply with applicable Australian standards or with American (AAR) standards in any cases where an Australian standard did not apply.

![Figure 2: Section of centre of wagon spine (not to scale)](image)

2.3 The SQDY wagons were of a type of construction referred to as ‘skeletal’. They had a fabricated hollow section central beam or ‘spine’ which ran the full length of the wagon supported at each end by a four-wheeled bogie. The
spines were fabricated from steel plates welded together to form a box section (see Figure 2).

2.4 The welded joint which failed in wagon SQDY 00060G was stated by ARI to be a ‘qualified joint’. ARI stated that this design of welded joint had been successfully used in the construction of about 10,000 other wagons in service in the USA including tankers, bulk hopper wagons and, notably, 40 ft container wagons.

2.5 The 40 ft container wagon was closest to the SQDY in design, having a single beam between the bogie platforms (see Figure 3). The wagon was designed to carry a single 40 ft container, but not two 20 ft containers, and had the qualified joint at its centre. A loaded 40 ft container, being rigid, will apply its gravitational force, and additional dynamic forces (caused by vertical accelerations generated by travelling over track features and imperfections), at its mounting points on the wagon on platforms over the bogies. No downward forces would be applied by the load to the longitudinal beam. In the case of tank or hopper wagons, the mass of the cargo would be more evenly spread over the wagon, including the qualified joint (see Figure 4).

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4 ‘Qualified Joint’: A welded joint that has been successfully tested using a set procedure which ‘qualifies’ it for future applications without the need for further testing.
2.6 SQDY wagons were designed to accept either a single 40 ft container or two 20 ft containers. To support the additional forces applied near to the centre of the wagon by the 20 ft containers, outriggers were fabricated with twist-locks to secure the containers. This design inevitably resulted in downward forces being applied close to the centre of the wagon; the midpoint of the longitudinal beam (see Figure 5). To cope with these forces, the longitudinal beam had been deepened in its centre and the steel used in the manufacture of the top
and bottom plates was increased from the ½" (12.7 mm) thickness used in previous designs to 5/8" (16 mm).

2.7 The location of the weld, in the mid position of the bottom plate of the central spine, is counter-intuitive. In a simple beam with a force applied in its centre, this is generally the location where the maximum bending forces and stresses apply. The SQDY wagon design deepened the beam in the centre, somewhat altering the location of maximum stress; it now occurred on the bottom beam at the transitions from the horizontal to angled sections. Even so, the location of this welded joint did introduce a potential failure point which could have been avoided through an alternative design.

2.8 ARI used Finite Element Analysis (FEA) to calculate stresses in the spine beam under 22 load cases. The highest stress calculated was under a hypothetical case where the full load was supported on the transverse outriggers located in the centre of the wagon. In this case, a factor of safety (allowable yield stress on weld material / maximum calculated stress) was calculated by ARI to be 1.65. However, the results provided by ARI have not been verified.

Joint Design and Fabrication

2.9 The wagon underframe was fabricated from steel plate with all joints being welded using a semi-automatic flux-cored arc welding method. A wagon frame under construction was rotated such that the position of the weld was always in a ‘natural’ position, that is, it was horizontal and beneath the welder. This made the task easier for the welders and assisted them in producing a satisfactory welded joint. When the welding of the joint was complete, the wagon frame was rotated 180 degrees with the central portion of the backing bar encapsulated on the inside of the wagon spine above the welded joint (see Figure 2).

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5 FEA: A method, using computer software, to calculate values in a complex environment (in this case the stresses involved throughout the fabric of the wagon under different loadings) by dividing the whole into small elements and calculating individual values of each in relation to the others. A graphic or pictorial image can then be produced showing patterns of magnitude including areas of maxima.
2.10 The weld was specified as being a ‘full penetration butt weld’ with backing bar with six weld runs (see Figure 6). The first weld run was to join one plate on to the backing bar. The second weld then joined the other plate to the backing bar and first weld. The next two welds were to fill the remainder of the gap between the plates, penetrating and fusing with the plates. The final two welds capped the joint, protruding above the plate surfaces.

Figure 6: Representation of ARI welding procedure (specifying ½” plate)

2.11 ARI’s documented welding procedure (WPS: A5786) specified ½” (12.7 mm) plate not the thicker 5/8” (16 mm) plate used in manufacture. The weld does not comply with the requirements for a pre-qualified weld under AS1554.1 2011 Structural Steel Welding. However, if a process was followed, compliant with part 4 of AS1554.1, then the weld could have been qualified for use as per ARI welding procedure A5786. ARI have not provided evidence that such a process was completed.

2.12 Australian Standard AS4100-1998 Steel Structures denotes square butt welds with backing plates, as used in this joint, as having a lower fatigue resistance than the parent material by a factor of about 0.3 to 0.4. Even if the weld was qualified as per AS1554.1 part 4, its use in a region of relatively high stress would be considered likely to fail prematurely due to fatigue.
2.13 Other designs of welded joints were available including one where the plate edges are bevelled to form a ‘V’ shape. In addition to providing a joint with a higher fatigue resistance (as per AS4100-1998), this type of weld would have been easier to perform consistently to the required standard.

2.14 The welding of the SQDY wagons did not comply with ARI’s own procedures and standards:

- The plate used was \(5/8\)” (16 mm) while the weld procedure specified \(1/2\)” (12.7 mm).
- The actual gap between the plates of wagon SQDY 00065F was smaller than the \(1/4\)” (6.36 mm) specified, being just over \(3/16\)” (5 mm). (It is not known what gap was present in the joint that failed in SQDY 00060G.)
- Weld terminations were not ‘ground flat’ in all cases and some displayed evidence of grinding marks or flame cutting on the plate edge.
- Welders had to be ‘qualified’ or ‘pre-qualified’ proficient to perform the weld. However, ARI was unable to provide documentary evidence that all the welders involved were correctly qualified.

2.15 OTSI has received engineering advice that the effective fatigue capacity of these welds could, without maintenance interventions, limit the operational life of these wagons.

Testing and Inspection of SQDY Wagons During Fabrication

2.16 ARI’s Non-Destructive Testing procedure, EN 1.07 Ultrasonic Inspection Scheme Through Sill Weld Joint, required that the first ten welds of the production run be ultrasonically tested, being without any defect. If any weld failed the test (i.e., a defect was detected) then testing must continue until ten consecutive welds passed. There were three welds of this type to be tested on each wagon. ARI records indicate that it was not until after the 35th wagon, representing the ultrasonic testing of 105 individual welds, that a sequence of ten consecutive welds passed ultrasonic testing. This indicates that the weld was difficult to perform to the required standard.
2.17 Once ten consecutive welds had passed ultrasonic testing, 13 subsequent wagon frames had all three welds tested (which exceeded the minimum requirement for 1 in 10) with no more ‘fails’ (defects) being recorded.

2.18 As one of the subsequent 13 wagons tested, the welded joint in wagon SQDY 00060G had been subjected to ultrasonic testing, but had ‘passed’ with no defects detected. ARI has suggested ‘operator error’ as a possible explanation for why no defects were found during the testing of this wagon. Ultrasonic testing (UT) was not performed on the welds of wagon SQDY 00065F, and nor did it have to be according to ARI’s UT regime.

2.19 The wagons were manufactured between 22 June 2011 and 22 August 2011. Wagons SQDY 00060G (the failed wagon) and SQDY 00065F (the other wagon identified as having a significant weld defect) were welded on consecutive days, 6 and 7 August respectively, with the welds performed by the same welder.

2.20 A number of wagons had welds with undercut present and/or poor weld terminations. Some had flame cut plate which had not been ground flat (see Photograph 4). Despite all the wagons undergoing visual inspections, the wagons were delivered to the customer without remedial work being undertaken.

Photograph 4: Flame cut edge
ARI Procedures

2.21 In addition to the EN 1.07 testing procedure, ARI had a number of procedures germane to this incident:

- Testing (‘Qualification’) of welders. Welders had to be tested for 10 welds and must have passed the last three. Subsequently, every tenth weld would undergo ultrasonic inspection.
- ARI Railcar Manufacturing Procedure EN 1.1, Ultrasonic Inspection Procedure – General, stated: “The transducer(s) shall be used with wedges producing an angle of refraction in the steel of approximately 70° for simple butt joints or as near to perpendicular to the angle of the line(s) of fusion as possible…”.
- ARI procedures also required a visual inspection to be undertaken as per the American Welding Society (AWS) specification D15.1:2007 Railroad Welding Specifications for Cars and Locomotives. The introduction on the AWS website states: “This specification establishes minimum standards for the manufacture of railroad equipment”. Section 17.2 sets out “Visual Inspection Acceptance Criteria” with maximum allowable sizes for craters, weld profile, undercut, porosity, etc.

QUBE Procedures

2.22 QUBE carried out a ‘Quality Audit’ of ARI in June 2011 as part of the SQDY wagon procurement process. The purpose of the audit was:

“..to conduct an external audit on ARI’s Quality systems for the following areas:

- Design
- Construction
- Worker competency
- Calibration, Measuring & Test Equipment
- Safety critical Components
- Parts & Consumables
- Commissioning”
The audit was conducted by the General Manager Engineering. The audit report concluded, in part: “The ARI quality systems were shown to be robust”. It also identified that: “ARI undergo annual quality audits from the American Association of Railroads (sic) (AAR) to remain certified”.

2.23 Once the wagons had entered service, in addition to train pre-departure inspections, a routine programme of periodic inspections commenced. The inspection scope and procedure was set out in a suite of QUBE documents including the Rail Safety Manual Procedures (Rolling Stock Maintenance Standards section), document WI-409 Instructions for PM Service. However, until the wagons had been in service for 12 months the only maintenance scheduled was regular 28-day visual inspections on the wagons.

2.24 The results of the 28-day inspections were recorded on form FM-660 Wagon PM Service Sheet (28-Day). SQDY 00060G had last undergone a 28-day inspection on 23/11/12 with the next being due on 21/12/12. Likewise, wagon SQDY 00065F underwent its 28-day inspection on the same date. The corresponding section on the Wagon PM Service Sheet (28-Day) form was ticked ‘OK’ for both wagons i.e., there were no defects found.

2.25 The 28-day inspections were carried out by QUBE’s wagon maintainer, Pacific Rail Engineering (PRE), with the results recorded on form FM-660. The Instructions for PM Service contained detailed servicing instructions which included, in part, in Section 3, Underframe and Body:

“3.1 Underframe – check underframe, mounting brackets, brake gear, centre plates and similar devices and repair as required

- Structural damage
- Cracks or broken welds ....”

2.26 Section 3.1, called for the detection of “cracks or broken welds”. However, the reality is that the inspection is a visual inspection only, carried out from the side of the wagon. To detect a crack such as existed in SQDY 00065F and (almost certainly) SQDY 00060G, on the underside of the wagon, the examiner would have had to crawl under the wagon. There is therefore a variance between the wording of section 3.1 and accepted practice. The visual inspection was such that it was unlikely that a minor crack or indeed a
significant crack in the location of the weld that failed would be detected. However, it would be reasonable to expect that a crack in the weld termination should have been detected, if present at the time of inspection (see Photograph 5).

**Photograph 5: Cracking of weld termination of SQDY 00065F**

2.27 The train crew of 8448N had completed a pre-departure safety inspection prior to departure from Gilgandra. While this inspection might not have been expected to pick up a cracked weld, had wagon SQDY 00060G been visibly sagging at this time it would have been noticeable to the person doing the inspection.

**Failure Mechanism of Wagon SQDY 00060G**

2.28 When the train was in draft (i.e., with locomotive power applied), train forces had the effect of keeping the wagon ‘stretched’ so causing the cracked side sills and the failed joint to partially close, with the top plate of the wagon being relatively straight. Under braking, the wagon would have experienced compressive forces of varying magnitudes depending on the dynamic forces created within the train. The in-train forces combined with the dynamic forces applied by the mass of the two loaded 20 ft containers would have caused the progressive failure of the sills.
2.29 The failure is likely to have developed from the same type of defect as evidenced in SQDY 00065F viz., an inter-run toe crack propagated through the weld which, lacking penetration and side wall fusion, failed. Once the welded joint had failed, bending forces transferred to the side sills. The sills then failed relatively rapidly, splitting vertically upwards from the weld (i.e., brittle failures, rather than stress fractures). As the sills split, the wagon sagged progressively in the middle (see Figure 7 and Photograph 6). Both sills eventually split from bottom to top with the top members of the two containers coming together so providing support and preventing any further downward deflection of the centre of the wagon.

![Figure 7: Representation of failure mechanism](image)
Bureau Veritas Inspection Procedures

2.30 Post incident, Bureau Veritas (BV) ultrasonically tested (UT) welds on the SQDY wagon fleet. BV used a UT procedure compliant with AS 2207 – 2007, *Non-destructive testing - Ultrasonic testing of fusion welded joints in carbon and low alloy steels*, test method UMB-2. This directs that for an angle of incidence (beam to welded face) of greater than 15° and up to 20°, an additional gain of 12 dB shall be used. BV used a 70° probe (as represented in Figure 8), which produced an angle of incidence of 20 degrees. This is very similar to the procedure used by ARI, which used a 70° probe and 10 dB gain. The 70° probe angle identified all the defects found with subsequent probes of different angles used to clarify the extent of the defect.
Bureau Veritas Analysis of Welded Joint

2.31 BV received the section including the defective welded joint found during post incident inspections and excised from wagon SQDY 00065F (see Photograph 7). BV subjected the section to metallurgical analysis and provided a report of their findings in March 2013. An extract from the report’s Executive Summary is reproduced below:

“Failure of the transverse mid wagon bottom plate weld was the result of fatigue cracking from the inter-run toe of the capping runs. Fatigue cracking propagated transversely through the weld until it intersected a lack of sidewall fusion flaw. The weld was found to contain significant extent lack of sidewall fusion and lack of penetration flaws which are considered to have contributed to the joint failure. No fusion was found to have been produced to the backing bar within the box section region of the joint.

The plate dimensions at 16mm thick were greater than the ½” (12.7mm) plate thickness indicated in the weld procedure. Similarly, the root gap plate separation was approximately 5mm which was slightly smaller than the minimum ¼” (6.36mm) separation specified by the weld procedure.”
2.32 While BV analysis detected six weld passes (as per the ARI weld procedure), neither of the first two passes had fused with or penetrated to the backing bar as required by the procedure (see Photograph 8). There was also a lack of side wall fusion.

Photograph 8: SQDY 00065F with the defective joint removed

2.33 BV concluded that:

“Failure of the transverse mid wagon bottom plate weld was the result of fatigue cracking from the inter-run toe of the capping runs. Fatigue cracking propagated transversely through the weld until it intersected a lack of sidewall fusion flaw.”

Photograph 9 shows the weld with cracks visible between the capping welds (in the ‘inter-run toe of the capping welds’).

2.34 BV recommended:

“A change in the weld preparation is recommended from the current square butt configuration to a single V preparation with backing bar. This construction would allow greater access to the root increasing the probability of full penetration and complete fusion while avoiding the need for time of flight testing to detect lack of side wall fusion flaws.”
Other Matters

2.35 As the SQDY wagons were a new item of rolling stock, authority had to be given to use them on the infrastructure of the various rail infrastructure managers (RIMs) - RailCorp, ARTC and JHR. All rolling stock in NSW is included in the respective RIM’s Train Operating Conditions (TOC) manual. Such inclusion, together with any special restrictions (such as geographical or speed restrictions), forms the authority for the rolling stock to operate. Until permanent inclusion in the TOC manual, subsequent to all necessary testing and inspections, authority may be granted by means of a TOC Waiver\(^6\). This is a document which allows operation for a specified period and, if necessary, under specified conditions.

2.36 RailCorp issued a TOC Waiver for SQDY wagons (Number 106-310) with period ‘from Tuesday 23 November 2011 until Monday 21 May 2012’. Subsequently, a further TOC waiver was issued (Number 107-152), valid from

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\(^6\) TOC Waiver: A temporary authority issued under a network owner’s procedures that allows non-standard or non-compliant rolling stock to operate on their network.
13 June until 10 December 2012. This TOC waiver was valid on the date of the incident.

2.37 ARTC issued TOC Waiver No. 11321, distributed 9 December 2011 and valid until 21 May 2012. There was neither a TOC waiver in force for the ARTC network at the time of the incident nor a relevant entry in their TOC manual.

2.38 JHR became a RIM in January 2012, taking over the operation of the Country Regional Network from ARTC. JHR did not issue a TOC waiver for SQDY wagons prior to the incident. JHR and the other two RIMS did issue TOC waivers immediately after the incident to allow the SQDY wagon fleet to be moved for inspection and repair.

2.39 Section 4.3.4 of the interface agreement between ARTC and JHR states:

“If either ARTC or JHRPL (JHR) become aware of an incident likely to affect infrastructure, operations or safety relating to the interface, they should ensure that the other organisation is advised as soon as possible.”

2.40 The incident was reported to ARTC train control in the early hours of 5 December but JHR was not informed about the incident and the possibility of infrastructure damage in a timely manner. A JHR track superintendent was informed by ARTC’s Binnaway Track Superintendent at about 1700 on 5 December and QUBE notified JHR Network Control at 1820 on the same day. There was no direct notification to JHR by ARTC train control staff.

**Safety Actions**

2.41 As a result of the incident and the Prohibition Notice issued by ITSR, all the SQDY wagons were visually inspected and ultrasonically tested by BV. As a result, they were categorised as 1, 2A, 2B or 3 as per the following criteria:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Inspection</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat 1</td>
<td>Welds in the likely affected areas that have been UT tested - no cracking of ANY length</td>
<td>Release for operations</td>
</tr>
</tbody>
</table>
The various categories and weld terminations are represented in the images contained in *Photograph 10*.

![Photograph 10: Post inspection categories](image_url)

Source: QUBE (modified)
2.42 Wagons 00060G and 00065F were the only two ‘Category 3’ wagons identified. Wagon 00060G was repaired while 00065F had the defective joint removed for analysis by BV (the plate being cut 200 mm away on either side of the joint). The missing section was then replaced with new steel. QUBE intends to return both wagons to service.

2.43 A number of wagons were found to have poor weld terminations, such as the example in Photograph 11. Some had flame cut edges and/or grinding marks that had not been corrected during the manufacturing process.

2.44 The wagons were repaired as necessary in conformance with ARI Engineering Instruction CF 098 issued on 20 December 2012.

Photograph 11: Poor weld termination
PART 3 FINDINGS

Causation

3.1 The structural failure of container wagon SQDY 00060G was due to the failure of the welded joint in the centre of the bottom member of the wagon’s spine.

Contributing Factors

3.2 The welding process specified by ARI had not been modified for the thicker plate used and the gap between the plates had not been increased commensurate with the increased thickness of plate. This made the weld technically difficult for the welder to perform.

3.3 The welding of the joint had not been performed proficiently. The weld had not penetrated through to or fused with the backing bar and the weld lacked side fusion with the steel plates.

3.4 The defective welded joint had not been detected during inspections, including Ultrasonic Testing, carried out as part of the manufacturing process.

3.5 The defective welded joint was not detected during routine maintenance inspections after the wagon had entered service.

Underlying Factors

3.6 The joint was of a square butt welded configuration. This type of joint is technically more difficult to perform than a ‘V’ type joint.

3.7 The design of the wagon placed a transverse welded joint in the centre of the bottom member of the central spine. As this is within a region of relatively high stress, it is not considered to be an optimum location for such a joint.

3.8 ARI was unable to provide records to demonstrate that all the welders who performed the welds were ‘qualified’ or otherwise proficient in the execution of this particular weld.

3.9 The standard of the final product was poor as evidenced by flame cut plate edges, poor weld finish, undercut welds and gaps present between plate and backing bar. These defects were not rectified before the wagons were placed in service.
Other Safety Matters

3.10 ARTC was slow to inform JHR of the incident and notification was made peer to peer by infrastructure workers. ARTC train control did not notify JHR of the incident in accordance with their interface agreement.
PART 4 RECOMMENDATIONS

To improve the safety of rail operations and prevent a recurrence of this type of incident, it is recommended that the following remedial safety actions be undertaken by the specified entities:

**QUBE Logistics (Rail) Pty Ltd**
4.1 Conduct independent in-service stress testing of sample SQDY wagons to provide hard data to allow verification of the integrity of the design with regard to the weld that failed in SQDY 00060G.

**American Railcar Industries Inc.**
4.2 Review its testing and inspection procedures to ensure that welding defects such as those which likely existed in a number of SQDY wagons can reliably be detected.
4.3 Note Bureau Veritas’ recommendation as to an alternative, potentially more effective and efficient, weld preparation configuration.
4.4 Review the processes and controls that ensure that wagons or other products supplied to the Australian market fully comply with Australian Standards.
4.5 Review its quality system to ensure that procedures provided to employees to perform a particular task are both suitable and current.
4.6 Review its record keeping system to ensure that records that demonstrate employee competencies are accurate, complete and retrievable.

**Australian Rail Track Corporation**
4.7 Implement, in accordance with current interface agreements, the processes for notifying rail infrastructure managers of adjacent networks of incidents or conditions that may have cross boundary implications.

**Office of the National Rail Safety Regulator**
4.8 Require that QUBE has appropriately certified the SQDY wagon design and its ongoing inspection requirements in accordance with their accreditation requirements or an appropriate Engineering Authority that references applicable rolling stock standards.
PART 5 APPENDIX

Appendix 1: Sources, Submissions and Acknowledgements

Sources of Information

- American Railcar Industries
- Australian Rail Track Corporation
- Australian Standards
- Australian Transport Safety Bureau
- Bureau Veritas
- John Holland Rail
- QUBE Logistics (Rail) Pty Ltd

Submissions

The Chief Investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- American Railcar Industries
- Australian Rail Track Corporation
- Bureau Veritas
- NSW Office of the National Rail Safety Regulator
- Pacific Rail Engineering
- QUBE Logistics (Rail) Pty Ltd

Submissions were received from American Railcar Industries, Australian Rail Track Corporation, the NSW Office of the National Rail Safety Regulator and QUBE Logistics (Rail) Pty Ltd.
The Chief Investigator considered all representations made by DIPs and responded to the author of each of the submissions advising which of their recommended amendments would be incorporated in the Final Report, and those that would not. Where any recommended amendment was excluded, the reasons for doing so were explained.

**Acknowledgements**

The technical advice and assistance of both the NSW Office of the National Rail Safety Regulator and the Australian Transport Safety Bureau is gratefully acknowledged.