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Case Study: Dump Trailer Kingpin Assembly Failure

By

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Subject

Examination of steel frameless end dump trailer, to determine the cause of the trailer tip-over. The trailer was visually inspected at an independent trailer repair location. A broken section of the trailer's frame supporting the trailer's hydraulic hoist was removed for testing. The testing methods conducted on this part were visual examination, chemical analysis, and hardness testing.

Visual Examination of Trailer

Figure 1 – Front End of Trailer

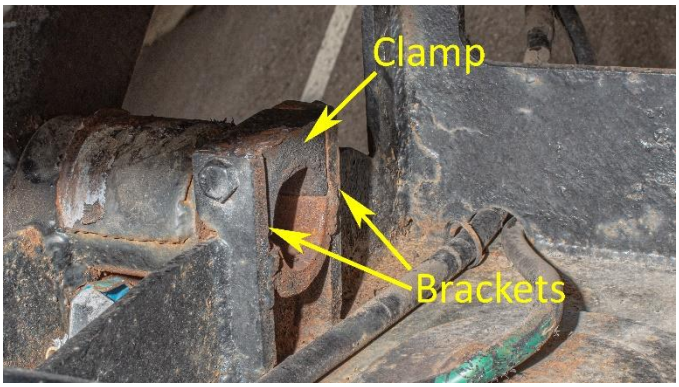

Figure 2 – Left Side Hoist Kingpin Pivot Bracket Assembly

Figure 1 shows the damage on the front end of the trailer. The kingpin plate and frame were significantly damaged in the trailer roll-over. The hoist was missing and was found in the bed of the trailer.

The left side of the hoist kingpin pivot bracket used to secure the hoist to the trailer frame is shown in Figure 2. The left hand assembly was intact at the time of examination. The kingpin pivot assembly consisted of four parts: two brackets, one clamp, and a nut and bolt to hold the clamp in place. There were significant amounts of wear and rust associated with the assembly. There was no visual evidence that the left side of the hoist assembly had ever been repaired. A section of the frame in this area may have been repaired.

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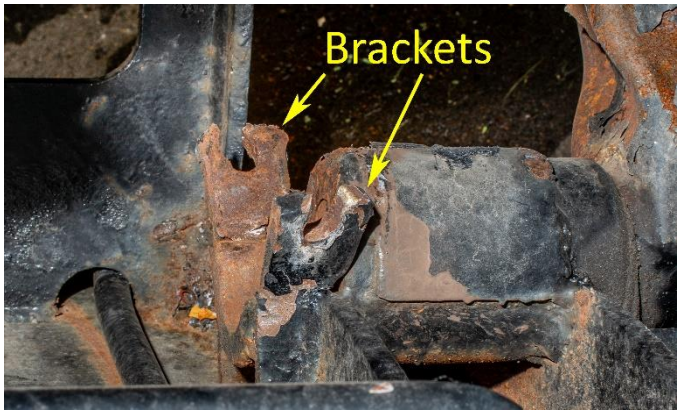

Figure 3 – Right Side Hoist Kingpin Assembly

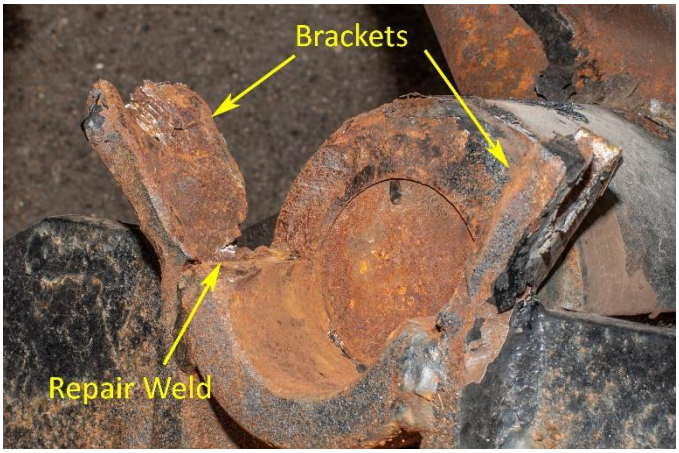

Figure 4 – Right Side Hoist Kingpin Assembly and Failure Location

The right side of the hoist kingpin assembly is shown in Figure 3. The assembly that held the kingpin in place was broken, and the nut and bolt and clamp were missing. This side of the trailer frame had been repaired at least once. The weld quality was extremely poor, indicating that the repairs were done by an unqualified welder. Figure 4 shows the defective repair weld. All welding standards and specifications require welds to pass visual inspection as a minimum. The repair weld was substandard and would not have passed a visual inspection.

Figure 5 shows another defective weld; having excessive reinforcement with weld filler metal as shown is not acceptable by any standards. Unfortunately, the standards for welding of on-road equipment are specified by the original equipment manufacturer, and many manufacturers do not have any standards. The repair welds in this case were not, even visually, comparable to the quality of the manufacturer's welds.

Figure 6 shows a bracket that broke, resulting in the trailer tipping over. This bracket had broken at least once before, and likely had broken several times, based on the conditions present. The upper arrow shows where the bolt hole in the bracket had pulled out and was then welded to repair it. The bracket had been repaired by welding in a small piece of steel, instead of replacing it with a solid piece, as on the front bracket and the front and rear brackets on the left side assembly. The bracket repair was removed in my presence by sawing.

Figure 7 shows the area after the bracket repair had been cut off. The welds holding the bracket to the trailer assembly were also defective.

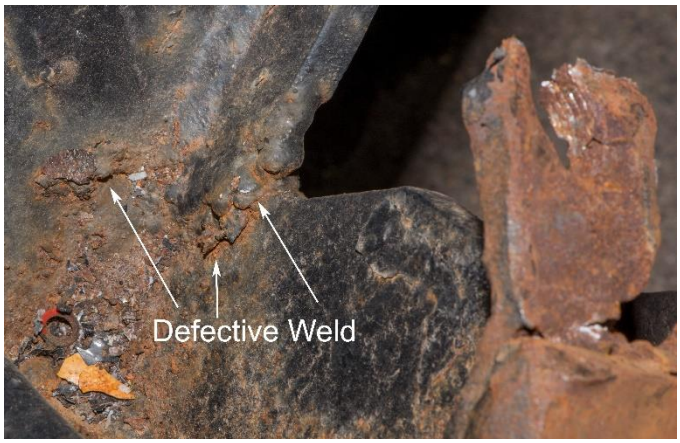

Figure 5 – Defective Welds Right Side

Figure 6 – Defective Welds Right Side - Rear Connection Bracket

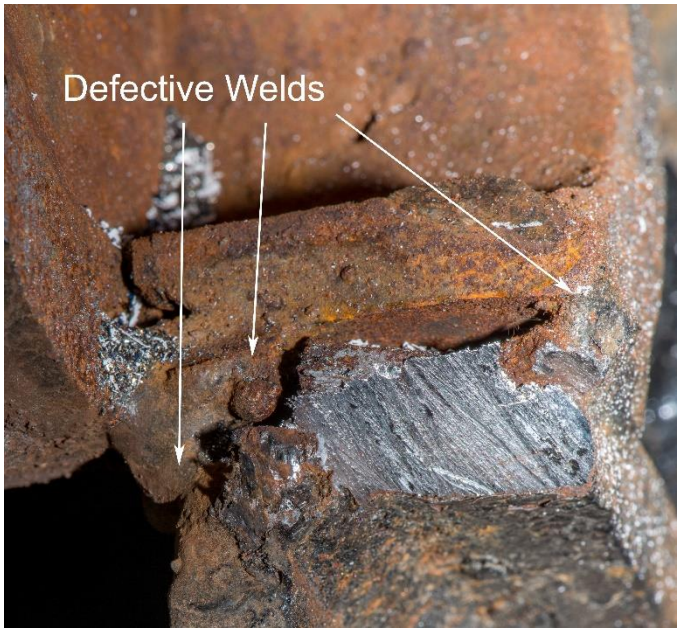

Figure 7 – Defective Welds Right Side - Rear Connection after Bracket Removal


Figure 8 – Hoist Base

The base of the hoist looked to be in good condition, Figure 8. It did not appear that the hoist contributed to the bracket failure.

Figure 9 – Bent Trailer Frame

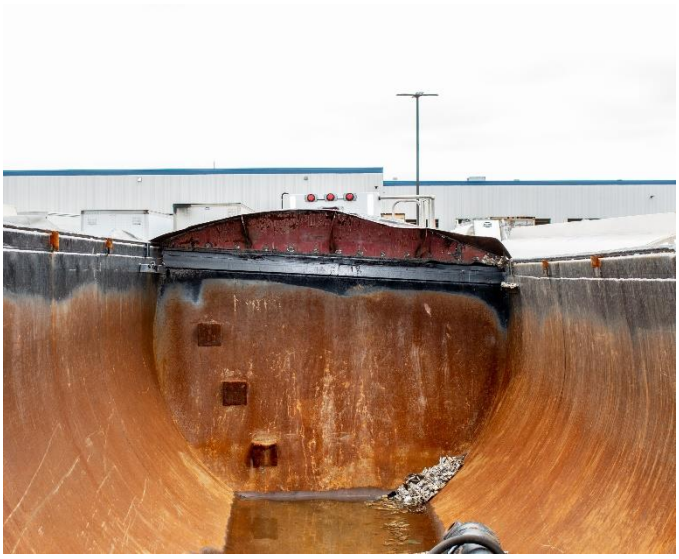

Figure 10 – Bent Trailer Frame

The tailgate of the trailer was used as a reference, shown in Figure 9. The tailgate was level with the ground, and shows that the trailer frame was bent. In Figure 10, the reference line of the top of the building showed that the bending extended the entire length of the trailer.

Bracket Evaluation

Visual Examination

Figure 11 shows the defective weld that was used to repair the bracket. The defects were excessive porosity and cracks. A metallographic cross section was made through the weld.

Figure 11 – Weld Porosity and Cracks on Bracket

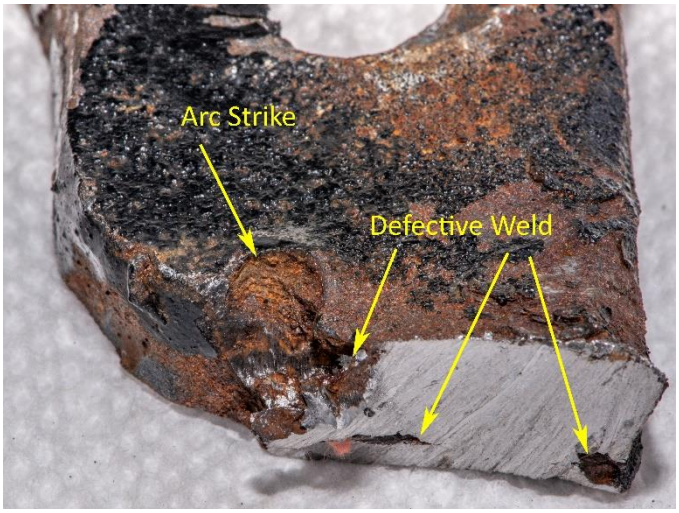

Figure 12 – Defective Weld at Base of Bracket

The weld at the base of the bracket is shown in Figure 12. This weld was defective, as shown by a lack of fusion and an unfilled arc strike. The welding on the bracket was done by an unqualified welder.

The weld at the base of the bracket has an allowable load of 9000 psi. The weld across the top of the bracket is not allowed, according to AWS D1.1, even if it had been of acceptable quality.

Chemical Analysis

The chemical analysis was done according to ASTM E1019 for carbon and sulfur, and E415 for the other elements. The results of the analysis are given in the table that follows.

Chemical Analysis of Bracket Steel
(Percent by Weight)

Element	Bracket Steel	1018
Carbon	0.20	0.15 - 0.20
Manganese	0.76	0.60 - 090
Phosphorous	0.019	0.040 Max.
Sulfur	0.010	0.050 Max.
Silicon	0.02	
Nickel	0.03	
Chromium	0.05	
Molybdenum	0.02	
Copper	0.02	

The chemical analysis showed that the steel used to fabricate the bracket was AISI/SAE 1018.

Hardness Testing

The hardness testing was done according to ASTM E384, using a Vickers indenter and a 500 gram load. The results of the testing are given in the table that follows. The values shown in the table were based on an average of six readings.

Hardness Test Data for Bracket Core
(Rockwell B Scale)

Location	Knoop	STD DEV	MAX VALUE	MIN VALUE	HARDNESS
Core	161.00	4.02	164.00	154.00	78.92 RB

The hardness of 79 on the Rockwell B scale indicated that the steel used was hot rolled AISI/SAE 1018. The steel had mechanical properties equivalent to ASTM A36 structural steel, which were not appropriate for a dynamically loaded welded assembly.

Opinion

It is my professional opinion to a responsible degree of scientific certainty based on the information available and discussed in this report that the following conditions resulted in the accident with the trailer:

1) The bracket supporting the right side of the trailer hoist base had been repaired several times; one of the repairs was welding a new bracket segment made from AISI/SAE 1018. This grade of steel was not of a high enough strength for this application. The welding of the bracket segment was defective, and the bracket segment had also been repaired previously by defective welding.

2) Examination of the weld repairs indicated that they were made by an unqualified weld operator.

3) The AISI/SAE 1018 steel was of insufficient strength for a dynamically loaded application.

4) The weld repair of the hoist bracket was not an allowable weld according to AWS D1.1.