



RCA Name Front Wheel Group - Hauler
 Report Number RCA 2012.1215
 Report Date 11/6/2012
 RCA Owner SOLOGIC EXAMPLE

Root Cause Analysis Report

Problem Statement

Focal Point Customer requests service credit

When

Start Date 11/6/2012
 Unique Timing This is always the case during scheduled overhauls on all Hauler trucks

Where

Location Salt Lake City, UT USA
 Site Bag End Mine
 System Ore Trucks (all types)
 Component Front wheel assembly, bearing and race, spindle and hub
 Component Wear appears on the weight-bearing (bottom) of spindle and race

Actual Impact

| | Cost |
|--|--------------------|
| Cost Overhead | 20,000.00 |
| Customer Service Perception of quality issue | |
| Actual Impact Total: | \$20,000.00 |

Frequency Notes It happens on every truck of this type... not unique to our products, but also occurs on our competition's products.

Potential Impact

| | |
|--|---------------------|
| Safety Potential risk due to additional machining requirements | 0.00 |
| Revenue Potential loss of revenue | 900,000.00 |
| Customer Service Potential long-term negative impact | |
| Potential Impact Total: | \$900,000.00 |

Report Summaries

Executive Summary

On 11/06/2012 we were notified by a customer that they wanted a service credit of \$20,000. The service credit was for machining of the front wheel spindles and bearing races for an ore hauler dump truck (used in mining) to bring them back into specification. Upon inspection, it was determined that these components had worn beyond specification. The customer wanted a credit because they mistakenly thought that the spindle damage was due to rotation of the bearing race against the shaft, which is not supposed to happen. This is not what occurred - however the customer misinterpreted evidence showing score marks on the spindle and on the inside of the bearing race. This misinterpretation occurred because they did not have complete information about the problem.

The wheel group required machining because during a scheduled rebuild, the spindles were discovered to be worn beyond specification. The rebuild process requires that the spindles be returned to original tolerances as outlined in the specification. It was determined that the wear was the result of downward pressure on the spindles/races along with slight side-to-side movement. This movement happens when the truck travels from the load site to the dump site. The length of the trip, the condition of the road, and the frequency of travel are all factors in the magnitude of the spindle/race wear. Movement also occurs when the truck is being loaded. If large pieces of rock are loaded first, and particularly if they are dropped from height, the truck will rock back and forth which causes wear on the spindles. This is a progressive phenomenon - it's less at first, and then the wearing accelerates as the gap gets larger. The spindle material hardness as well as the fit between the spindles and races are also factors, however neither was out of specification.

Two areas were hypothesized as potential causes of the scoring/wear: 1) Scoring during disassembly of the wheel group or, 2) Scoring during installation. Evidence shows that neither of these was a factor.

Solutions

| ID | Label | Description | | |
|-----------|-----------------|--|-----------------|-------------|
| 1 | Solution | Specify larger bearings in future designs. | | |
| | Cause | Specification = 14.9985" +/- 0.0005" | | |
| | Note | Provide to the design team for evaluation. This may not be economically feasible, but it's possible that this design change will pencil out. | | |
| | Assigned | Brian Hughes | Criteria | Pass |
| | Due | 1/18/2013 | Status | Approved |
| | Term | Long | Cost | \$0.00 |
| | | | | |
| 2 | Solution | Contact Loctite - is there a better product for binding these parts/taking up additional space? | | |
| | Cause | Movement between spindle and race | | |
| | Note | This is not a solution per se, however we need to gather information about the types of bonding products available. We may be able to make a better bond during the preload process. | | |
| | Assigned | Marcus McCoy | Criteria | Not Checked |
| | Due | 12/28/2012 | Status | Approved |
| | Term | Short | Cost | \$0.00 |
| | | | | |
| 3 | Solution | Conduct periodic preload adjustments | | |
| | Cause | Movement between spindle and race | | |
| | Note | During periodic maintenance cycles, include the preload adjustment to account for any slack that occurs. This will help keep the components tightly fitted together and reduce the damage. | | |
| | Assigned | Choose | Criteria | Pass |
| | Due | 1/11/2013 | Status | Approved |
| | Term | Short | Cost | \$1,000.00 |
| | | | | |
| 4 | Solution | Compare road conditions with other clients. Identify a list of benefits from keeping the roads in better shape. | | |
| | Cause | Road conditions | | |
| | Note | Road conditions cause/accelerate other maintenance issues as well... not just this one. We will help conduct the survey... the customer would be responsible for maintaining their roads. | | |
| | Assigned | Marcus McCoy | Criteria | Pass |
| | Due | 1/18/2013 | Status | Approved |
| | | | | |
| | | | | |

| | | | | |
|---|-----------------|--|-----------------|------------|
| | Term | Medium | Cost | \$1,000.00 |
| 5 | Solution | Recommend speed limits based on road conditions. | | |
| | Cause | Time/duration of trips | | |
| | Note | This works in combination with the road conditions... the better the conditions, the faster the trucks can travel while minimizing damage. | | |
| | Assigned | Chris Eckert | Criteria | Pass |
| | Due | 1/18/2013 | Status | Approved |
| | Term | Medium | Cost | \$1,000.00 |
| 6 | Solution | Confirm specification/hardness. | | |
| | Cause | Hardness of spindle | | |
| | Note | We need to double check the hardness of the spindle material. It needs to be flexible enough not to crack yet hard enough to maximize wear. | | |
| | Assigned | Chris Eckert | Criteria | Pass |
| | Due | 1/18/2013 | Status | Approved |
| | Term | Medium | Cost | \$500.00 |
| 8 | Solution | Review loading techniques... adjust style to improve longevity of equipment | | |
| | Cause | Force from loading the truck | | |
| | Note | If soft material is loaded first and then harder, larger material, it will minimize the amount of motion transferred to the truck during the loading process. | | |
| | Assigned | Chris Eckert | Criteria | Pass |
| | Due | 1/18/2013 | Status | Approved |
| | Term | Medium | Cost | \$500.00 |
| 9 | Solution | Revise the way we communicate with our customer on service orders. Include pictures. Provide customer with examples upon next site visit. | | |
| | Cause | Customer had incomplete information | | |
| | Note | This is something that we've needed to do for a long time. We have other communication breakdowns - they lead to misunderstandings that are always counter-productive. | | |
| | Assigned | Brian Hughes | Criteria | Pass |
| | Due | 12/28/2012 | Status | Approved |
| | Term | Short | Cost | |

Team

| ID | Label | Description | Label | Description |
|-----------|-------------------|--------------------------|------------------|--------------------|
| 1 | First Name | Chris | Last Name | Eckert |
| | Phone (1) | 989-835-3402 | Phone (2) | |
| | Role | Reliability Engineer | Group | |
| | Email | chris.eckert@sologic.com | | |
| 2 | First Name | Brian | Last Name | Hughes |
| | Phone (1) | 206-282-7703 | Phone (2) | |
| | Role | Participant | Group | |
| | Email | brian.hughes@sologic.com | | |
| 3 | First Name | Marcus | Last Name | McCoy |
| | Phone (1) | 989-835-3402 | Phone (2) | |
| | Role | Participant | Group | |
| | Email | marcus.mccoy@sologic.com | | |

Evidence

| ID | Label | Description |
|-----------|--------------------|---|
| 1 | Evidence | Observation of damaged parts |
| | Cause(s) | Dissassembly problem? Installation problem? Bearing/race did not rotate Front wheel group requires machining |
| | Location | |
| | Link | |
| | Contributor | Chris Eckert |
| | Type | Direct Observation |
| | Quality | ★★★★★ |
| 2 | Evidence | Statements from mechanic |
| | Cause(s) | Actual < specification tolerance Customer misunderstands the problem Customer believes bearing/race rotated Customer misinterpreted the evidence Misunderstanding indicated rotation Customer had incomplete information Score marks found on spindle, bearing race |
| | Location | |
| | Link | |
| | Contributor | Chris Eckert |
| | Type | Direct Statement |
| | Quality | ★★★★☆ |
| 3 | Evidence | Photos of worn parts |
| | Cause(s) | Actual < specification tolerance |
| | Location | Kris Venkeitswaran phone |
| | Link | |
| | Contributor | Brian Hughes |
| | Type | Photo/Video |
| | Quality | ★★★★★ |

4

Evidence Micrometer measurements

Cause(s) Front wheel group is worn beyond specification
Actual < specification tolerance

Location

Link

Contributor Chris Eckert

Type Instrumentation

Quality ★★★★★

5

Evidence Rebuilding guidelines

Cause(s) Rebuild process requires returning to specification

Location

Link

Contributor Chris Eckert

Type Document

Quality ★★★★★

6

Evidence Specification

Cause(s) Specification = 14.9985" +/- 0.0005"
Mass of truck
Hardness of spindle
Rebuild process requires returning to specification

Location Document: Truck Spec

Link

Contributor Chris Eckert

Type Choose

Quality ★★★★★

7

Evidence Statement from experts

Cause(s) Load force (mass of truck + load)
Movement between spindle and race
Dissassembly problem?
Installation problem?
Fit between front wheel group components

Force from moving along the road
 Force from loading the truck
 Road conditions
 Number of movement cycles
 Time/duration of trips
 Mass of payload pieces
 Height of payload drop
 Load technique (softer material first, harder material last)

Location

Link

Contributor Marcus McCoy

Type Direct Statement

Quality ★★☆☆☆

8 **Evidence** Measurements/observations from customer site

Cause(s) Road conditions
 Number of movement cycles
 Time/duration of trips
 Mass of payload pieces
 Height of payload drop
 Load technique (softer material first, harder material last)

Location

Link

Contributor Marcus McCoy

Type Document

Quality ★★★★★

9 **Evidence** Customer Statements

Cause(s) Customer misunderstands the problem
 Customer believes bearing/race rotated
 Misunderstanding indicated rotation
 Customer had incomplete information
 Customer misinterpreted the evidence

Location

Link

Contributor Chris Eckert

Type Direct Statement

Quality



Chart Type Legend

- ▶ Transitory
- Non-transitory
- ▶ Omission - Transitory
- Omission - Non-transitory
- ★ Focal Point
- ⊙ Solution Implemented

