I-CAR ADVANTAGE Online™
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Technical Information For The Collision Industry

# DIAGNOSING A BENT STEERING KNUCKLE USING ALIGNMENT DATA

When performing steering angle diagnostics, it is not easy to verify if a steering knuckle is damaged. Due to their size and design, even when they are bent, it is not typically obvious. Steering knuckles are heavy cast parts made of steel or aluminum. They are not repairable and should be replaced if damaged.

A damaged steering knuckle could be discovered anytime during the collision repair process. For that reason, many times a damaged knuckle escapes replacement up to the point of the vehicle getting an alignment. That is the situation we will be addressing for this article.

## READING ALIGNMENT DATA

For purposes of this article, we are looking at the alignment data for a vehicle with a strut-type suspension. While trying to adjust camber on the left front wheel, the suspension cannot be adjusted enough to move camber to the specified value. There are a number of problems that could cause this condition, so further diagnostics are required to identify what is damaged.

We will take you through the actual steps of diagnosing this problem using an Alignment Angle Diagnostic chart and the alignment printout data. These charts are located on pages 4 to 8 of this document. Even though we are doing this using a strut-type suspension, the same concepts can also be applied to solid axle and short-arm, long-arm (SLA) suspensions.

The Alignment Angle Diagnostic chart uses the SAI, camber, and included angle measurements to narrow down the possible list of causes for an alignment problem.
To use the Alignment Angle Diagnostic chart, first start by locating the correct suspension type. Then look at the actual (Before) steering axis inclination (SAI) measurement on the alignment report. Determine if SAI is greater than the specified angle, less than the specified angle, or the correct angle. In this example, the specification is 12.7° and the actual angle is 12.7°. Therefore, mark the Alignment Angle Diagnostic chart in the multiple areas that indicate Correct SAI (see Figure 1 page 6).

Next, do the same for camber, and make marks on the Alignment Angle Diagnostic chart that corresponds with the condition of the camber angle. In this example, the specification for camber is -1.2°, and the actual measurement is -0.2°. This makes the camber greater than specification. Therefore, mark the Alignment Angle Diagnostic chart in the multiple areas that indicate Greater Camber (see Figure 2 page 7).

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Lastly, compare the actual included angle reading to the specified included angle, and make a check on the Alignment Angle Diagnostic chart that corresponds with the current position of the included angle. In this example, the actual included angle is 12.5° which is greater than the specification of 11.5°. Therefore, mark the Alignment Angle Diagnostic chart in the multiple areas that indicate Greater Included Angle (see Figure 3 page 8).

Looking at the Alignment Angle Diagnostic chart for a MacPherson Strut Suspension, in the row where SAI is Correct and Camber and Included Angle are Greater, the listed possible causes are a bent strut and/or a bent knuckle.

## VISUAL INSPECTION

To determine which of these parts is bent, additional diagnostics are needed. A detailed visual inspection may help uncover signs of damage and should be the next step in the diagnostics process. One way to look for signs of damage may include using an LED flashlight to look for signs of flaking coatings or corrosion on the steering knuckle. Some people prefer the use of an LED flashlight because of the blue-colored light that the LED bulbs emit (see Figure 4). When a cast part is bent, it may disturb and loosen any coatings or corrosion that has built up on the part if the degree of the bend is severe enough. Minor damage, however, may not show any visible signs and will require measuring to positively identify.

## MEASUREMENT CHECKS

Typically, there is no measuring data available for steering knuckles or struts. Therefore measuring quick checks used to identify damage to these parts must be done comparatively to a known good part, such as the opposite side of the vehicle.

To test the strut cartridge for damage, a straightedge may be placed along the side of the strut cartridge to look for areas where there are gaps between the straightedge and the strut (see Figure 5). Another, and more positive, test that can be done to test for a bent strut cartridge is to measure from a straightedge placed on the hub face to symmetrical locations on the strut. When measuring the strut in this manner, make sure that struts that have camber adjustments, where the strut and steering knuckle are connected, are adjusted to the same position on the left and right side of the vehicle.

The strut can also be tested by doing a strut-rotation quick-check. To do this, loosen the lock nut at the upper strut bearing one-half to one full turn. Do not completely remove the lock nut. Then using a wrench or locking pliers, rotate the strut rod shaft a minimum of 360° while observing the top of the tire for in-and-out movement or camber change. Changes in camber as the strut rod is rotated indicate a bent strut rod shaft.

Steering knuckle measuring quick-checks are done very similar to those for a strut cartridge. A straightedge is placed against the hub or brake rotor and measurements are made from the straightedge to points on the steering knuckle. If the brake rotor is used, ensure that it is held tightly to the hub with lug nuts. Measure to at least two different points, one where the steering knuckle and strut are connected. Differences in the measurements between the part being tested to a known good part indicate a bent steering knuckle (see Figure 6).

Though not identified by SAI, included angle, or camber, the steering arm on the knuckle should also be measured to ensure it is not bent. To do this, the steering arm distance can be measured between the end of the steering arm, where the tie rod connects, and a symmetrical part attached to the knuckle, like the axle joint or bearing assembly. The steering arm position can also be measured to a straightedge placed against the hub or rotor. This measurement helps determine if the steering arm is moved in or out in relationship to its intended location. Also, the steering arm should be measured to a symmetrical location on the upper

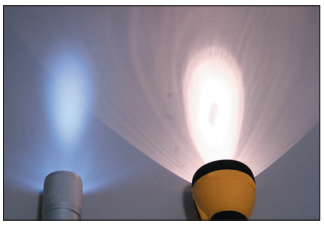

*Figure 4– Different colored light may help show corrosion.*

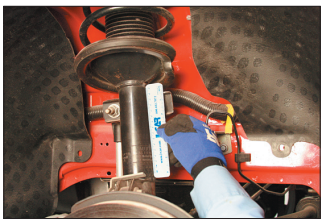

*Figure 5– Small straightedges can be used to check for a bent strut cartridge.*

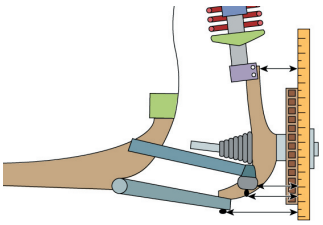

*Figure 6– Record and compare measurements from side to side.*

Continued From Page 2

or lower control arm. This measurement checks for vertical movement in the steering arm.

When measuring a steering knuckle or a steering arm for movement towards or away from the vehicle centerline, where the straightedge is placed is critical. Placing the straightedge on the face of the hub, or against the rotor may not provide a true measurement if the rotor or hub assembly is damaged. Ensure that parts being used as a measuring reference are not damaged. In some situations, the diameter of the rotor or the dust shield may impede access to the steering arm. A small tram bar can be used to measure around obstacles or the steering arm can be measured with the straightedge being placed on the front of the knuckle if the rotor and hub and bearing assembly are removed.

## CONCLUSION

When trying to determine if a steering knuckle is bent, multiple steps may be needed to either rule out or confirm whether the part needs replacement. Keep in mind that replacement is key. Steering knuckles are made of cast steel or cast aluminum, neither which are repairable or should be heated. If the part is damaged, replacement is the only option.

Which process is used is your decision, but before a knuckle is condemned, make sure it was analyzed properly.

More information on diagnostic angles can be found in the I-CAR Live Steering And Suspension Damage Analysis (DAM06) and Wheel Alignment And Diagnostic Angles (STE04) programs.

For comments or suggestions on the Advantage Online, please contact I-CAR Senior Instructional Designer Bob Jansen at bob.jansen@i-car.com.

**I-CAR ALIGNMENT**
**123 Somewhere, WI 54914**
**(920) 555-1212**

**Technician:** John Smith **Time:** 2:46 pm **Date:** 01/25/2008
**Customer:** John Doe

| **Vehicle: Year** | **Make** | **Model** | **Odometer** |
|---|---|---|---|
| 1998 | I-CAR | 4 door sedan | 48234 |

## VEHICLE ALIGNMENT REPORT

| | Left Front | | | Right Front | | |
|---|---|---|---|---|---|---|
| | Spec | Before | After | Spec | Before | After |
| **CASTER** | 3.10° | 3.10° | ---- | 3.10° | 3.10° | ---- |
| **CAMBER** | -1.2° | -0.2° | ---- | -1.2° | -1.2° | ---- |
| **TOE** | 0.07" | 0.07" | ---- | 0.07" | 0.07" | ---- |
| **SAI** | 12.7° | 12.7° | ---- | 12.7° | 12.7° | ---- |
| **INCLUDED ANGLE** | 11.5° | 12.5° | ---- | 11.5° | 11.5° | ---- |
| **MAX TURN** | ---- | ---- | ---- | ---- | ---- | ---- |

# ALIGNMENT ANGLE DIAGNOSTICS

| SLA-Style Suspension - Double Wishbone - 4-Link - SLA | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Lower Control Arm/Bent Structure/Camber Adjustment |
| Greater | Less | Correct | Bent Upper Control Arm/Bent Structure/Camber Adjustment |
| Less | Greater | Greater | Bent Lower Control Arm/Bent Structure/Bent Knuckle (Spindle) |

| MacPherson Strut Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle (Spindle) and/or Strut |
| Correct | Greater | Greater | Bent Knuckle (Spindle) and/or Strut |
| Less | Greater | Correct | Bent Control Arm/Strut Out At Top (Bent Structure/Adjustment) |
| Greater | Less | Correct | Strut In At Top (Bent Structure/Adjustment)/Shifted Cradle |
| Greater | Greater | Greater | Strut Tower In–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Greater | Greater | Strut Tower Out–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Less | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |
| Less | Greater | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |

| Solid Axle Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Axle Housing/Beam |
| Greater | Less | Correct | Bent Axle Housing/Beam |
| Less | Greater | Greater | Bent Axle Housing/Beam and Bent Knuckle/Spindle |
| Greater | Less | Less | Bent Axle Housing/Beam and Bent Knuckle/Spindle |

Figure 1–Correct SAI is marked for ease of diagnosis.

## ALIGNMENT ANGLE DIAGNOSTICS

| SLA-Style Suspension - Double Wishbone - 4-Link - SLA | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Lower Control Arm/Bent Structure/Camber Adjustment |
| Greater | Less | Correct | Bent Upper Control Arm/Bent Structure/Camber Adjustment |
| Less | Greater | Greater | Bent Lower Control Arm/Bent Structure/Bent Knuckle (Spindle) |

| MacPherson Strut Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle (Spindle) and/or Strut |
| Correct | Greater | Greater | Bent Knuckle (Spindle) and/or Strut |
| Less | Greater | Correct | Bent Control Arm/Strut Out At Top (Bent Structure/Adjustment) |
| Greater | Less | Correct | Strut In At Top (Bent Structure/Adjustment)/Shifted Cradle |
| Greater | Greater | Greater | Strut Tower In–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Greater | Greater | Strut Tower Out–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Less | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |
| Less | Greater | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |

| Solid Axle Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Axle Housing/Beam |
| Greater | Less | Correct | Bent Axle Housing/Beam |
| Less | Greater | Greater | Bent Axle Housing/Beam and Bent Knuckle/Spindle |
| Greater | Less | Less | Bent Axle Housing/Beam and Bent Knuckle/Spindle |

Figure 2–Camber is marked to help narrow down the possible damaged parts.

## ALIGNMENT ANGLE DIAGNOSTICS

| SLA-Style Suspension - Double Wishbone - 4-Link - SLA | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Lower Control Arm/Bent Structure/Camber Adjustment |
| Greater | Less | Correct | Bent Upper Control Arm/Bent Structure/Camber Adjustment |
| Less | Greater | Greater | Bent Lower Control Arm/Bent Structure/Bent Knuckle (Spindle) |

| MacPherson Strut Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle (Spindle) and/or Strut |
| Correct | Greater | Greater | Bent Knuckle (Spindle) and/or Strut |
| Less | Greater | Correct | Bent Control Arm/Strut Out At Top (Bent Structure/Adjustment) |
| Greater | Less | Correct | Strut In At Top (Bent Structure/Adjustment)/Shifted Cradle |
| Greater | Greater | Greater | Strut Tower In–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Greater | Greater | Strut Tower Out–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Less | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |
| Less | Greater | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |

| Solid Axle Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Axle Housing/Beam |
| Greater | Less | Correct | Bent Axle Housing/Beam |
| Less | Greater | Greater | Bent Axle Housing/Beam and Bent Knuckle/Spindle |
| Greater | Less | Less | Bent Axle Housing/Beam and Bent Knuckle/Spindle |

Figure 3–After included angle is marked, suspected suspension damaged parts can be checked.

## *ALIGNMENT ANGLE DIAGNOSTICS*

| SLA-Style Suspension - Double Wishbone - 4-Link - SLA | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Lower Control Arm/Bent Structure/Camber Adjustment |
| Greater | Less | Correct | Bent Upper Control Arm/Bent Structure/Camber Adjustment |
| Less | Greater | Greater | Bent Lower Control Arm/Bent Structure/Bent Knuckle (Spindle) |

| MacPherson Strut Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle (Spindle) and/or Strut |
| Correct | Greater | Greater | Bent Knuckle (Spindle) and/or Strut |
| Less | Greater | Correct | Bent Control Arm/Strut Out At Top (Bent Structure/Adjustment) |
| Greater | Less | Correct | Strut In At Top (Bent Structure/Adjustment)/Shifted Cradle |
| Greater | Greater | Greater | Strut Tower In–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Greater | Greater | Strut Tower Out–Plus Bent Knuckle (Spindle) Or Strut |
| Less | Less | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |
| Less | Greater | Less | Strut Tower Out Or Bent Control Arm–Plus Bent Knuckle Or Strut |

| Solid Axle Suspension | | | |
|---|---|---|---|
| **SAI** | **Camber** | **Included Angle** | **Probable Cause** |
| Correct | Less | Less | Bent Knuckle/Spindle |
| Correct | Greater | Greater | Bent Knuckle/Spindle |
| Less | Greater | Correct | Bent Axle Housing/Beam |
| Greater | Less | Correct | Bent Axle Housing/Beam |
| Less | Greater | Greater | Bent Axle Housing/Beam and Bent Knuckle/Spindle |
| Greater | Less | Less | Bent Axle Housing/Beam and Bent Knuckle/Spindle |