U.S. Department of Transportation
**National Highway Traffic Safety Administration**

# ODI RESUME

Investigation: EA03-023
Prompted By: PE03-032
Date Opened: 11/19/2003 Date Closed: 02/11/2005
Principal Investigator: Peter Kivett
Subject: Upper Ball Joint Separation

Manufacturer: DaimlerChrysler Corporation
Products: MY 1997-2003 Dakota and MY 1998-2003 Durango
Population: 1,788,534

Problem Description: The front suspension upper ball joint allegedly separates while driving.

**FAILURE REPORT SUMMARY**

| | ODI | Manufacturer | Total |
|---|---|---|---|
| Complaints: | 90 | 94 | 164 |
| Crashes/Fires: | 11 | 5 | 14 |
| Injury Incidents: | 2 | 2 | 3 |
| # Injuries: | 3 | 3 | 4 |
| Fatality Incidents: | 0 | 0 | 0 |
| # Fatalities: | 0 | 0 | 0 |
| Other*: | 0 | 0 | 0 |

*Description of Other:

Action: This Engineering Analysis is closed. Recall 04V-596.

Engineer: *Peter Kivett* PHK Date: *02/10/2005*
Div. Chief: *Jeffrey L. Quandt* Date: *02/10/2005*
Office Dir.: *Kathleen C. DeMeter* Date: *02/10/2005*

Summary: DaimlerChrysler Corporation (DCC) is recalling the target population of approximately 600,000 model year 2000 through 2003 Durango and Dakota vehicles with four-wheel drive to replace the front suspension upper ball joints with redesigned parts that do not have the joint integrity concerns and have substantially improved joint retention capacity (NHTSA Recall No. 04V-596). Though DCC does not admit to a safety-defect in the subject components, ODI believes that the facts in this investigation show otherwise.

Because of the low rates of separation incidents in the remaining subject vehicles, a safety-related defect has not been identified in those populations and further use of agency resources does not appear to be warranted. The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists in those vehicles. The agency reserves the right to take further action if warranted by the circumstances.

For additional information, see the attached closing report.

PHK @ 2:15 FEB 11th 05

**ENGINEERING ANALYSIS CLOSING REPORT**

**SUBJECT:** Front Suspension Upper Ball Joint Separation.

**EA No:** EA03-023 **Date Opened:** 19-Nov-2003 **Date Closed:** 11-Feb-2005

**BASIS:** On July 16, 2003, ODI opened a Preliminary Evaluation (PE03-032) to investigate allegations of front suspension upper ball joint separation in model year (MY) 1998 through 2002 Dodge Durango sport utility vehicles manufactured by DaimlerChrysler Corporation (DCC). On November 19, 2003, the investigation was upgraded to an Engineering Analysis (EA03-023). During EA03-023, ODI collected information on approximately 1.8 million MY 1998 through 2003 Durango vehicles and MY 1997 through 2003 Dodge Dakota pickup trucks equipped with front suspension upper ball joints using two-piece plastic bearings (subject vehicles).

**RECALL 04V-596:** On November 23, 2004, ODI requested that DCC recall approximately 600,000 MY 2000 through 2003 Durango and Dakota vehicles with four-wheel drive (target vehicles). On December 10, 2004, DCC verbally informed NHTSA that it would recall the target vehicles. DCC provided written notification to NHTSA in a letter dated December 15, 2004. DCC took this action without admitting a safety-related defect.

**ALLEGED DEFECT:** Front suspension upper ball joint separation (Figure 1).

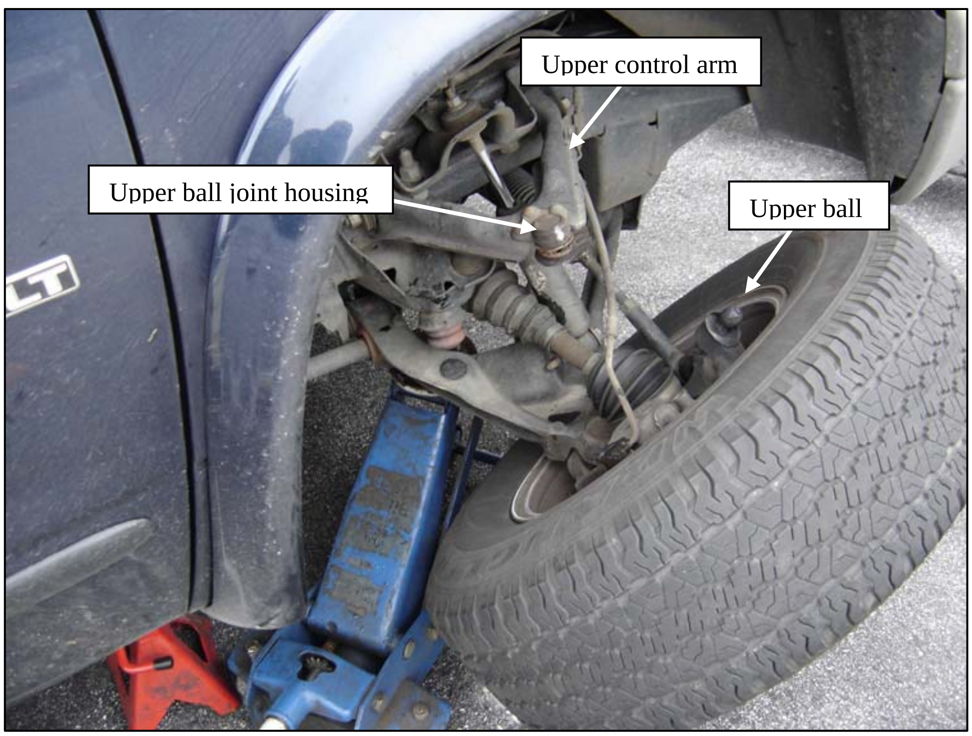


Figure 1. Front suspension upper ball joint separation –
MY 2001 Dodge Dakota 4x4 - 57,400 miles – 5 mph.

**<u>SUBJECT COMPONENT DESCRIPTION</u>:** The subject vehicles are equipped with independent short-long arm (SLA) front suspensions (Figure 15). The lower control arms carry the sprung mass of the vehicle through the coil springs (two-wheel drive) or torsion bars (four-wheel drive). The lower arm is configured to the steering knuckle so that the weight of the vehicle acts to compress the lower ball joints, which are the load-bearing joints in the front suspensions of the subject vehicles. The upper ball joints are stabilizer or follower type joints, which are in moderate compression during static (curb) load conditions.[1]

**Subject components.** The subject front suspension upper ball joints are maintenance-free, "lubed-for-life" joints that are common to the two-wheel drive and four-wheel drive subject vehicles. Figure 2 shows a cutaway view of a subject ball joint without the lubricant. The subject joints use a two-piece plastic (acetal) bearing. TRW supplied the upper ball joints for the MY 1997 through 1999 Dakota and the MY 1998 through 1999 Durango vehicles. The design life of the TRW parts is 10 years/100,000 miles. Beginning with the MY 2000 vehicles, DCC changed to an internal supplier, New Castle Machining and Forge (NCM).[2] The design life of the NCM parts is 10 years/150,000 miles. In January 2003, DCC changed the ball joints to a one-piece bearing design to address concerns with upper roll crimp integrity.

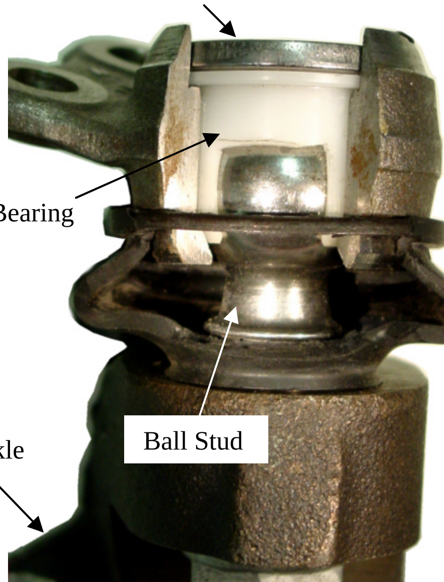


Figure 2. Upper ball joint cutaway (one-piece bearing).

The ball joints are riveted to the upper control arms and, until August 2003, were serviced with the control arm as an integral unit. In August 2003, DCC released a new service procedure with service kits for the MY 1997-99 vehicles (P/N 05104788AA/AB) and MY 2000-03 vehicles (P/N 05014816AA/AB) to allow the upper ball joints to be replaced separately.

[1] The subject upper ball joints are predominantly in side (lateral) load at curb and during steady state driving.
[2] In January 2004, DCC sold NCM to Metaldyne Corporation.

**<u>FAILURE MECHANISM</u>:** The failure mechanism is corrosive/grinding wear of the ball and housing due to evacuation of joint lubrication. There are two general causes for the lubrication loss, both of which involve compromised joint integrity: (1) a leak path through the upper crimp joint; or (2) a leak through or around the lower seal/boot. While DCC documents describe design and manufacturing issues that contribute to both conditions, DCC has identified the former as the primary cause of premature upper ball joint failures in the subject vehicle population.

Once the joint seal has been compromised, the defect condition proceeds through the following stages: (1) intrusion of water and other foreign material into the joint; (2) degradation and evacuation of joint lubrication; (3) joint bearing wear; (4) corrosion (Figure 3b); (5) abrasive wear of the joint ball and socket interface from metal-to-metal contact, outside contaminants, and wear debris; and (6) in joints with free-play, a combination of corrosive/grinding and impact wear of the ball and housing throat which can result in separation of the ball from the socket while driving (Figure 3c).

**a) New.** **b) Bearing degradation, corrosion and metal-to-metal grinding wear.** **c) Ball and housing throat wear - joint separation.**

Figure 3. Failure mechanism, NCM ball joint.

**<u>CONTRIBUTING FACTORS</u>:** There are three primary factors that contribute to joint separations in the subject vehicles: (1) compromised joint seal integrity at the upper crimp or boot, resulting in premature wear-out; (2) the larger throat opening of the NCM joint design; and (3) differences in suspension design, joint articulation, loading, and wear in four-wheel drive vehicles. Use conditions that may influence the rate of joint wear and separation risk include driving cycle, road conditions, and environment.

**Joint integrity.** DCC has identified a joint integrity condition in the upper ball joints of the subject vehicles related to the use of the two-piece bearings. According to DCC, the bearings in these parts may interfere with the upper roll crimp, creating a water intrusion path and a minor loose fit issue as built (Figure 4).


Figure 4. Two-piece bearing with ball stud (left), upper crimp water intrusion path (right).

In addition, DCC documents describe concerns with the boot seal that may lead to leakage. Boot seal leaks also compromise the joint integrity. Conditions that cause boot/seal failure have been the subject of several safety recalls involving front suspension lower ball joints.

**Throat opening.** The NCM ball joints have a significantly larger throat opening than the TRW joints (Figure 5), which reduces the amount of force and material wear required to induce separation once lubrication is lost. The NCM ball joints have a rectangular shaped throat opening that is approximately 22 millimeters wide, resulting in about 5 millimeters of retention interference with the stud ball, which is 27 millimeters in diameter. This represents a 35 percent reduction in retention interference from the TRW joint, which has a throat opening that is 19.3 millimeters wide. In short, NCM joints have less metal to retain the ball in the socket than the TRW joints.

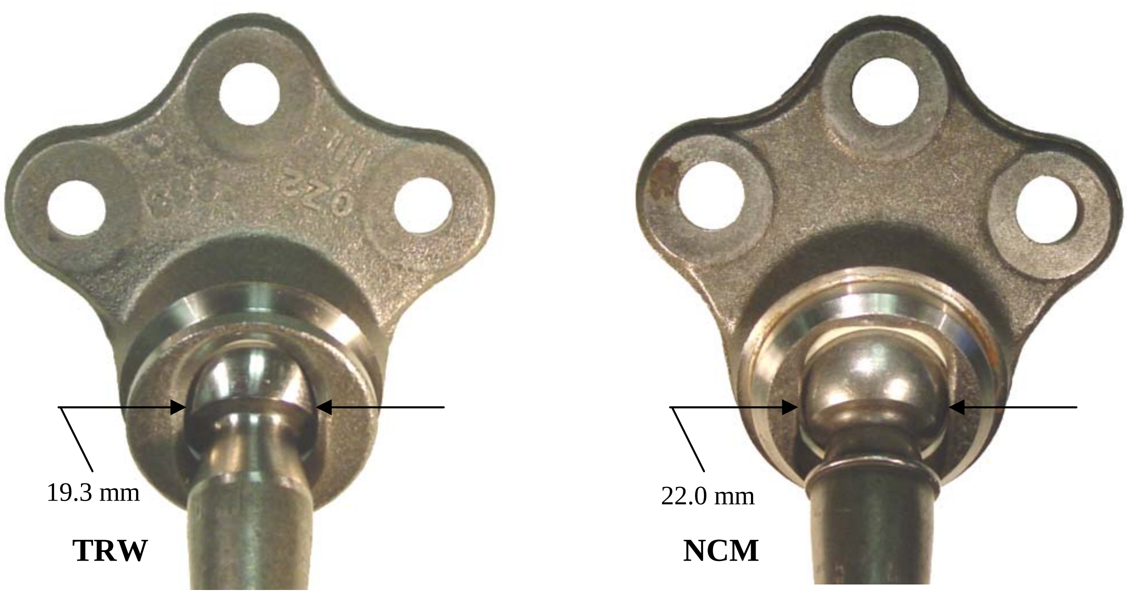


Figure 5. Upper ball joint throat opening, TRW and NCM.

In addition, joint dimensional and tolerance data provided by DCC for the NCM and TRW joints show that metal-to-metal contact dimensions between the ball and socket in the throat area are about [redacted] percent lower in the NCM joints than the TRW joints. Test data provided by DCC for new parts indicate that separation forces for the NCM joints are about [redacted] percent lower than the

TRW joints. The NCM and TRW test specimens exhibited different modes of separation in the testing, as TRW joints could not be separated without [redacted] [redacted] while VRTC testing showed that NCM joints could be separated by pulling the ball through the throat opening.

ODI's measurements of separated NCM parts returned from the field has found that corrosive wear caused increases in the throat opening averaging about 4.1 millimeters and decreases in the minimum ball diameter averaging about 2.2 millimeters, resulting in parts with no retention force. Figure 6 shows two examples of separated NCM joints, including whether they are among those counted by DCC as related to the issue under investigation.

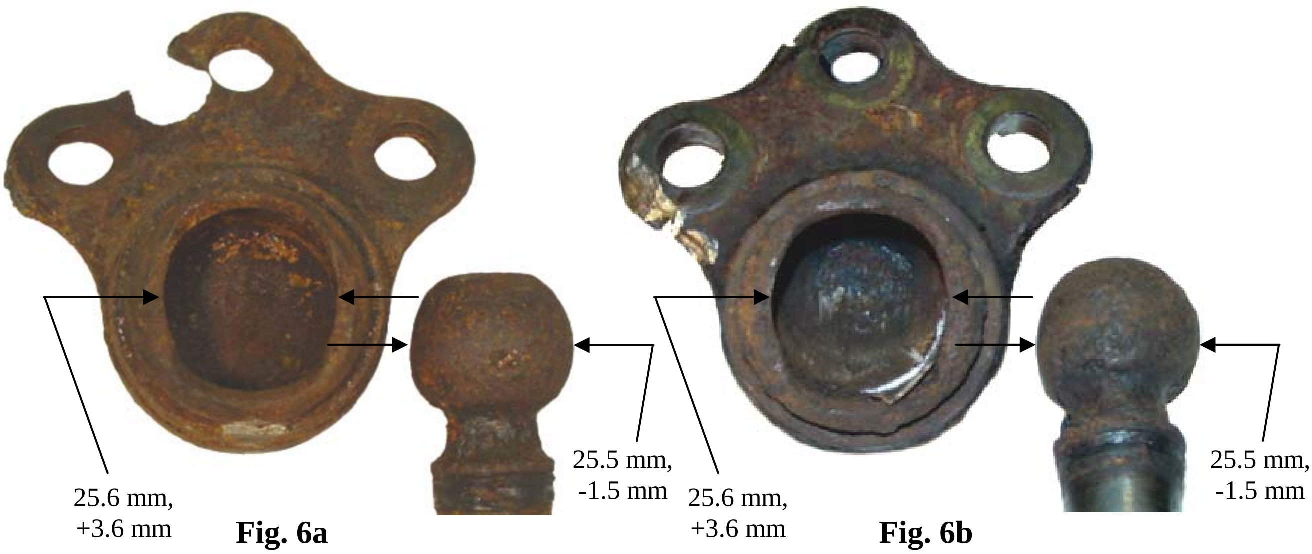


Figure 6. Separated NCM upper ball joints:
6a) MY 2000 Dakota 4x4 – 50,002 miles – 45 mph – 0.485 inches end-play – DCC count = NO[3]; and
6b) MY 2000 Dakota 4x4 – 79,000 miles – 50 mph – 0.460 inches end-play – DCC count = YES.

**Service loads.** The subject ball joints have low service loads in comparison to the lower tension-type ball joints that were the subject of most of the front suspension ball joint investigations and recalls over the past 10 years. However, the subject ball joints are subjected to substantial vertical, lateral, and longitudinal loads during transient driving conditions, such as cornering, which occur frequently during routine service. These loads contribute to wear that occurs in a joint with compromised seal integrity. Because of the design of the NCM joint, premature wear can progress more rapidly to the level where retention capacity is lost, allowing separation to occur with virtually no load.

The data indicate that the joint articulation and service loads are greater in the four-wheel drive vehicles. While the upper ball joints are the same, the upper control arm in the four-wheel drive vehicles is shorter by about 62 millimeters than in the two-wheel drive vehicles. This results in greater joint articulation in the four-wheel drive vehicles, which may cause more wear at the ball-socket interface. The vehicle mass and front suspension un-sprung mass are also greater in the four-wheel drive vehicles, which also contribute to the joint loads and wear.

[3] Categorized by DCC as "Insufficient information available," see DCC's POSITION (Table 6).

Test data furnished by DCC show that the loads on the upper ball joints are greater in the four-wheel drive than in the two-wheel drive vehicles. Figures 16a and 16b show the respective vertical load vs. speed cross plots for the two-wheel drive and four-wheel drive vehicles run in the light-as-possible condition on DaimlerChrysler's Ball Joint Evaluation Road Course, which was designed to simulate "normal everyday driving conditions."[4] In addition, joint loads and resulting wear on the ball and socket during cornering, braking, and low speed turning contribute to the dimensional changes in the ball and socket that can lead to separation. Evidence that joint wear is greater in the four-wheel drive vehicles is found in the joint wear data from DCC's vehicle survey (see ADDITIONAL INFORMATION).

**<u>DESIGN/PROCESS CHANGES</u>:** To address the concerns with joint durability, DCC introduced a running change to a one-piece bearing design during MY 2003 production. During 2003, DCC implemented changes to improve [redacted] In early-2004, additional changes were made to the ball joint design and manufacturing process to improve [redacted]. In mid-2004, the supplier redesigned the ball joints used as service replacement parts to substantially improve joint sealing and ball retention (e.g., narrowing the housing throat opening by 3.5 mm). The ball retention interference is increased by 70 percent in the new upper ball joints (Figure 7). The new parts also have a secondary seal applied to the upper crimp. These parts (Metaldyne ball joints) are being used by DCC in Recall 04V-596 and as the current service parts.

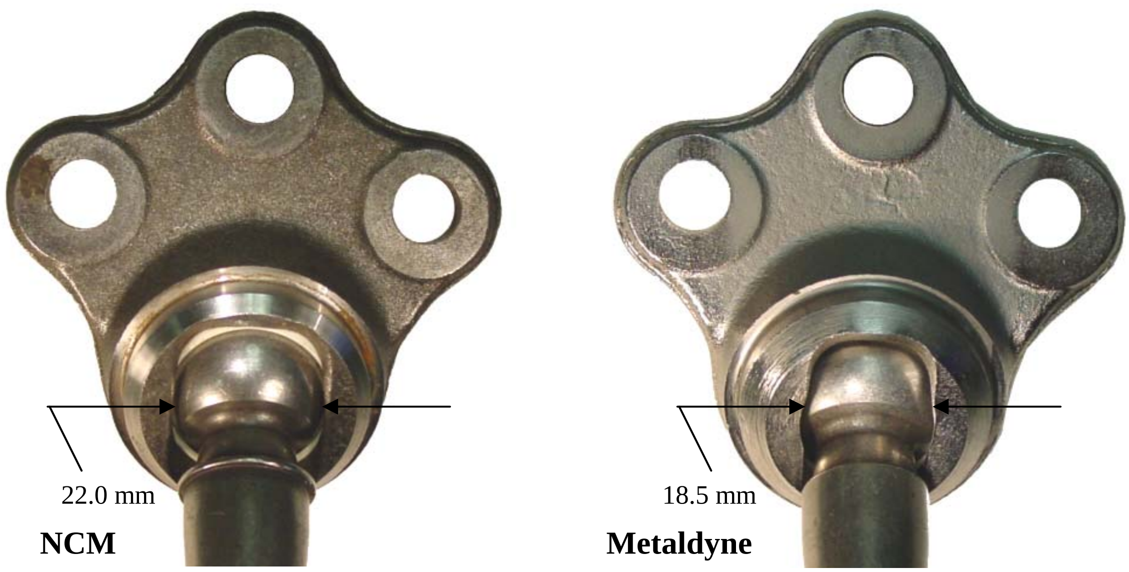


Figure 7. Housing throat opening change, NCM to Metaldyne service/recall part.

**Dealer communication.** In August 2003, DCC issued a dealer communication that changed the service procedures for upper control arm ball joints in the subject vehicles. Previously, the dealers were required to replace the upper control arm to repair an upper ball joint condition. This procedure also required a front-end toe alignment to be performed, adding to the cost. DCC

[4] This was DCC's Public Road Event testing. The same course was used in the 8-mile noise evaluation drive in DCC's field survey.

implemented the change to simplify and reduce the cost of upper ball joint replacement by revising the repair procedure to allow the ball joints to be serviced without replacing the upper control arm. The procedure involved grinding an “X” through the rivet heads securing the upper ball joints to the upper control arm, then chiseling the rivet heads off and punching the rivets through the arm. The new ball joint is then attached to the upper control arm with three bolts and nuts supplied in the kit.

**POPULATION:** Table 1 shows the sales volumes by drivetrain, model, and model year for subject vehicles equipped with TRW ball joints. DCC sold approximately 742,000 vehicles with TRW ball joints, including about 420,000 four-wheel drive and 322,000 two-wheel drive vehicles.

| Model Year | Two-Wheel Drive | | | Four-Wheel Drive | | | Total |
|---|---|---|---|---|---|---|---|
| | Dakota | Durango | Total | Dakota | Durango | Total | |
| 1997 | 81,953 | -- | 81,953 | 46,794 | -- | 46,794 | 128,747 |
| 1998 | 111,390 | -- | 111,390 | 41,044 | 123,068 | 164,112 | 275,502 |
| 1999 | 82,092 | 46,593 | 128,685 | 52,055 | 157,412 | 209,467 | 338,152 |
| Total | 275,435 | 46,593 | 322,028 | 139,893 | 280,480 | 420,373 | 742,401 |

Table 1. Subject vehicle population, TRW two-piece upper ball joints.

Table 2 shows the sales volumes by drivetrain, model, and model year for subject vehicles equipped with NCM two-piece ball joints. DCC sold approximately one million vehicles with NCM two-piece ball joints, including about 592,000 four-wheel drive and 454,000 two-wheel drive vehicles.

| Model Year | Two-Wheel Drive | | | Four-Wheel Drive | | | Total |
|---|---|---|---|---|---|---|---|
| | Dakota | Durango | Total | Dakota | Durango | Total | |
| 2000 | 114,185 | 53,262 | 167,447 | 72,732 | 142,432 | 215,164 | 382,611 |
| 2001 | 88,378 | 38,045 | 126,423 | 70,278 | 99,404 | 169,682 | 296,105 |
| 2002 | 77,971 | 35,726 | 113,697 | 67,285 | 76,535 | 143,820 | 257,517 |
| 2003 | 30,003 | 16,567 | 46,570 | 28,936 | 34,394 | 50,961 | 109,900 |
| Total | 310,537 | 143,600 | 454,137 | 239,231 | 352,765 | 591,996 | 1,046,133 |

Table 2. Subject vehicle population, NCM two-piece upper ball joints.

The production data for the MY 2003 vehicles is through December 2002. According to DCC, revised ball joints with one-piece bearing that were not susceptible to joint integrity concerns were implemented in production in January 2003. DCC produced approximately 165,400 MY 2003 through 2004 Dakota vehicles and 71,300 MY 2003 Durango vehicles with the one-piece bearing ball joints. The MY 2004 Durango and MY 2005 Dakota are redesigned vehicles.

**PROBLEM EXPERIENCE:** Both ODI and DCC received large numbers of complaints relating to premature wear-out of front suspension upper ball joints in the subject vehicles. Table 10 shows the numbers of complaints related to upper ball joint wear received by DCC through January 22, 2004 and by ODI through February 4, 2005. In the ODI complaints where the drivetrain was identified or could be determined from the vehicle identification number, the rate in the four-wheel drive vehicles was more than double the rate in the two-wheel drive vehicles.

The complaints to ODI represent 56 percent of all front suspension ball joint complaints received over the last 10 years and 79 percent of such complaints involving all MY 1998 and later production vehicles. The subject vehicles comprise less than two percent of all MY 1998 and later light vehicle sales in the United States. Figure 17 shows the vehicles with the highest ODI complaint rates for front suspension ball joints over the last 10 years by model and model year. Eleven of the top 17 rates are subject vehicles. All of the vehicles with higher rates were involved in recalls and are older than the subject vehicles. Figure 18 shows the ODI complaint rates for the subject vehicles in comparison to peer sport utilities and pickup trucks. The subject vehicle rates are much higher.

After analyzing all the available information, including DCC's complaint analysis (see DCC's POSITION), ODI identified a total of 164 separation incidents in the subject vehicles (Table 3). The data include incidents reported to DCC up to July 29, 2004 and to ODI through November 30, 2004. Of the 164 separations identified by ODI, 141 involve vehicles with NCM ball joints and 120 of those involve the target vehicles with four-wheel drive. Twelve of the alleged crashes and all of the alleged injury incidents involve target vehicles.

| Category | ODI | DCC | Total (duplicates omitted) |
|---|---|---|---|
| Complaints | 90 | 94 | 164 |
| Crashes | 11 | 5 | 14 |
| Injury incidents | 2 | 2 | 3 |
| Injuries | 3 | 3 | 4 |

Table 3. Failure report summary.

ODI verified these complaints using information from the complaints, DCC's data, and follow-up calls with consumers. Regarding the latter, ODI attempted to contact all of the consumers whose complaint allegations indicated a potential upper ball joint separation incident – particularly if the initial complaint was ambiguous or contained insufficient information. ODI took statements from the consumers and collected repair documents, towing receipts, police reports, photographs, and parts where available. These figures do not include a number of potentially relevant complaints where ODI was unable to contact the consumer and the available information remains inconclusive.

**WARRANTY:** The subject ball joints have failed at low mileage and have exhibited high warranty claim rates to address conditions related to loss of lubrication (e.g., excessive wear, insufficient lubrication, loose, noisy). ODI's analysis of warranty claim data indicates that the subject vehicles would experience extremely high replacement rates for upper ball joints within 100,000 miles of service and that the problems would continue at high frequencies thereafter. The data indicate that, in some regions of the country, some segments of the subject vehicle population would exceed 50 percent failure rates within 100,000 miles. The rates are very high and are increasing at the end of the warranty period (Figure 8). The warranty terms for the subject vehicles are 36 months/36,000 miles.

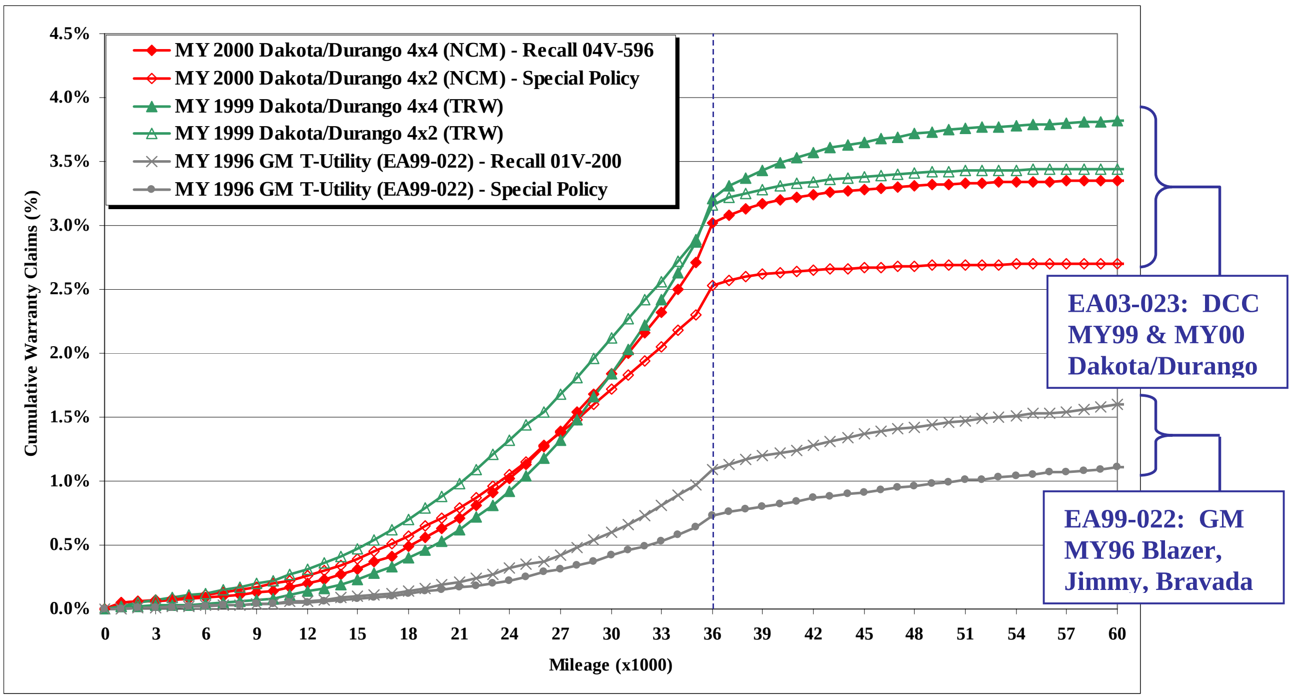


Figure 8. Cumulative warranty claim rates,
subject vehicles vs. EA99-022 recall and special policy populations.

DCC does not believe the warranty experience of the subject vehicles is high and stated in a December 10, 2004 letter responding to ODI's recall request that ODI's characterization of it as such was "without benchmark."[5] ODI notes that when the subject vehicle warranty rates and trends are compared to another population of vehicles investigated and recalled for upper ball joint separations (EA99-022),[6] the subject vehicle rate is three times higher at the end of the warranty period and increasing more rapidly (see Figure 8).

Figure 9 shows the warranty claim rates by month of build by 6-month service intervals. The rates are high for both the TRW and NCM equipped subject vehicles. Aside from a peak in the

[5] DCC also stated in its December 10, 2004 letter, "The warranty numbers provided to ODI were not limited to claims of loose, noisy, and worn upper ball joints." ODI notes that 92 percent of the warranty claims on the target vehicles are coded "Excessive Wear," "Insufficient Lubrication," "Loose," or "Noisy." The remaining eight percent include other potentially relevant codes (e.g., "Broken or Cracked").

[6] MY 1996 General Motors (GM) T-Utility (Chevrolet Blazer, GMC Jimmy, and Oldsmobile Bravada four-wheel drive utility vehicles) upper and lower ball joint separation.

TRW data toward the end of MY 1999 production, the NCM equipped vehicles generally show higher claim rates for each service interval. The NCM rates increase for MY 2002, with the monthly rates in the period from December 2001 to April 2002 exceeding all prior months at the 12-, 18- and 24-month service intervals.

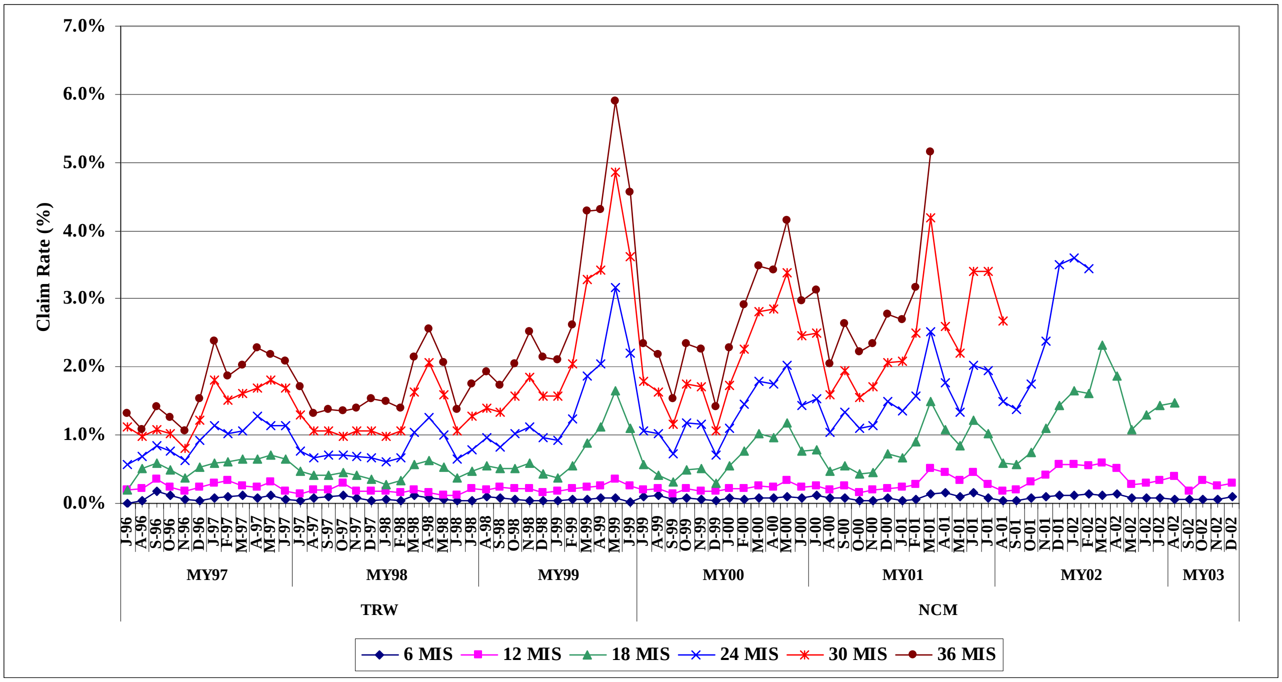


Figure 9. Warranty claim rates by month of build and service interval.

Table 11 provides a summary of the warranty claim counts and rates by model, model year, and drivetrain. The data are high for all of the subject vehicles.

**Returned part analysis.** In response to an information request (IR) in EA03-023, DCC furnished warranty return information regarding 175 upper ball joint repair claims, involving a total of 242 joints, on MY 2000 through 2003 subject vehicles. The warranty return claims are a little over 10 percent of all upper ball joint claims in the period from late-October to early-December 2004. About 82 percent of the return claims involved ball joints with end-play that was below DCC's service replacement specification, 0.060 inches. DCC claims this is evidence that owners are detecting and repairing worn joints before they progress to unsafe levels of wear.

The return program was conducted during the period when publicity concerning the alleged defect was heaviest. CBS News ran its first story on the investigation on October 27, 2003. One may infer that in the aftermath of this and subsequent CBS stories, an increased number of consumers sought inspections and service for upper ball joint wear. The end-play measurements from the returned parts for this period of time cannot, therefore, be considered representative of all warranty claims. Nevertheless, about seven percent of the warranty return vehicles had an upper ball joint with end-play exceeding 0.2 inches, including one joint with 0.398 inches of end-play from a MY 2001 Dakota two-wheel drive pickup with 28,587 miles.

Upper crimp leakage was detected in an upper ball joint in a large percentage [redacted] of the warranty return vehicles. Concerns with boot condition were noted in upper ball joints in over [redacted] of the vehicles.

**<u>PART SALES</u>:** Part sales data provided by DCC show very high sales for upper control arm assemblies and, following release of the service kits in August 2003, upper ball joints for the subject vehicles. Table 4 shows the annual sales volumes for the TRW and NCM equipped vehicles from 1999 through early-March 2004. Total sales of these parts over this period reached about 27 percent of the TRW vehicle population and 12 percent for the NCM vehicles. Demand for the NCM upper ball joint kit was high and increasing, with over 7,400 units sold in January 2004. It should be noted that many post-warranty repairs use aftermarket replacement parts that are not included in the Table 4 figures. In addition, survey data show that many vehicles requiring new ball joints have not been repaired (see ADDITIONAL INFORMATION).

| Ball Joint Supplier | Part Description | Sales | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | |
| TRW | Upper control arm, 4x2 | 6,992 | 11,245 | 10,821 | 7,529 | 6,185 | 677 | 43,449 |
| | Upper control arm, 4x4 | 11,398 | 25,398 | 33,052 | 50,328 | 22,210 | 1,538 | 143,924 |
| | Ball joint kit, 4x2 or 4x4 | -- | -- | -- | -- | 6,818 | 677 | 12,569 |
| | Total | 18,390 | 36,643 | 43,873 | 57,857 | 35,213 | 7,966 | 199,942 |
| NCM | Upper control arm, 4x2 | 52 | 1,015 | 4,835 | 10,808 | 16,781 | 2,070 | 35,561 |
| | Upper control arm, 4x4 | 82 | 1,256 | 7,933 | 17,345 | 24,500 | 2,402 | 53,518 |
| | Ball joint kit, 4x2 or 4x4 | -- | -- | -- | -- | 22,953 | 14,166 | 37,119 |
| | Total | 134 | 2,271 | 12,768 | 28,153 | 64,234 | 18,638 | 126,198 |

Table 4. Part sales, upper control arm assemblies and upper ball joint kits.

**<u>ADDITIONAL INFORMATION</u>:**

**VRTC noise evaluation.** To evaluate DCC's claim that a driver would receive an audible warning from a badly worn ball joint long before the joint could separate, engineers at NHTSA's Vehicle Research and Test Center (VRTC) in East Liberty, Ohio performed test drives to evaluate the noise produced by a ball joint with over 0.2 inches end-play in a four-wheel drive Durango vehicle leased from DCC. The history of this joint is unknown (e.g., age, mileage, side, 4x2/4x4 usage). The VRTC engineers found that the noise was intermittent and was masked by the radio or other noises that can occur during starts, stops, bumps, depressions, and other transient conditions that may cause relative motion between a loose ball and socket.

**VRTC survey.** The VRTC engineers also conducted a survey in the Columbus, Ohio area to assess the condition of the upper ball joints in the subject vehicles and some peer vehicles. The survey found that, for vehicles with 100,000 miles of service or less, most of the subject vehicles and none of the peers had loose upper ball joints.

The VRTC engineers measured upper ball joint radial-play in 13 MY 1998 through 2000 Durango vehicles and 17 peer sport utility vehicles of similar age and with 100,000 miles or less of service (Figure 10). The survey found loose upper ball joints in 10 of the 13 subject vehicles

(77%), including 4 of the 6 vehicles with NCM ball joints (67%).[7] The greatest radial-play was recorded in a target vehicle with just 36,000 miles – the lowest mileage of all the survey vehicles.

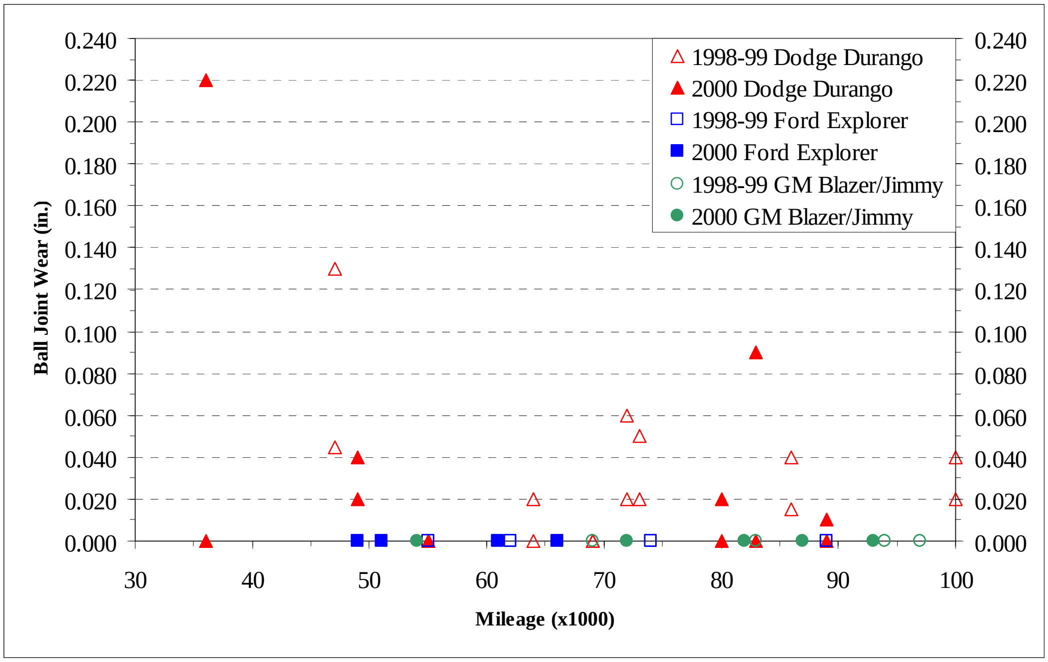


Figure 10. VRTC field survey results.

The GM vehicles included in the survey were the subject vehicles of RQ02-012 (Blazer, Jimmy, and Bravada sport utility vehicles), a peer investigation DCC has cited as comparable in upper ball joint separation rate to the subject vehicles. No ball joint radial-play was detected in the 18 Ford and GM vehicles with 100,000 miles or less of service.

**Failed part analysis.** To assess the joint wear characteristics associated with separation incidents, ODI and VRTC engineers measured and sectioned several parts that had been involved in separations or had excessive levels of end-play. These analyses found increases in the throat opening of the separated parts that averaged 4.11 millimeters, ranging from 3.53 to 6.87 millimeters. The ball, socket, and bearing wear were irregular. The wear pattern was generally greatest in the upper-inboard area (see Figures 3c & 19b). Greater wear was also observed on the front surface of the ball and the corresponding bearing/socket interface. This is attributed to the forces from braking torque transmitted through the knuckle to the ball stud. Figure 19 shows the early stages of this wear pattern in a joint with 0.26 inches end-play. The wear pattern is more pronounced in the separated parts (Figures 20-21).

The reductions in minimum ball diameter averaged 2.22 millimeters, ranging from 1.49 to 3.62 millimeters. Considering that the retention interference in the parts when new is just five millimeters in the NCM joints, each of the joints had no retention force remaining when they separated. Any driving condition that produced relative vertical movement between the upper control arm and steering knuckle could result in a joint separation at these wear states.

[7] Joints with 0.02 inches or more of radial-play are counted as loose in this analysis.

Analysis of the parts also indicates the amount of axial end-play associated with loss of retention force. ODI and VRTC determined the maximum end-play for six separated ball and socket pairs by measuring the axial play at each rotational orientation where the ball could not be simply pulled from the socket. Figure 11 shows the device used by ODI to measure end-play in this manner. The measured end-play averaged 0.501 inches, ranging from 0.460 to 0.590 inches. The median end-play was 0.482 inches. VRTC also photographed three of the joints after sectioning to show the ball position at approximately 0.5 inches and 0.8 inches from contact with the joint cap (Figures 20, 21, and 22). This analysis shows that risk of separation in the subject upper ball joints is much greater once end-play exceeds 0.4 inches than is indicated by DCC's technical reviews, which show that retention exists at much higher levels of wear.

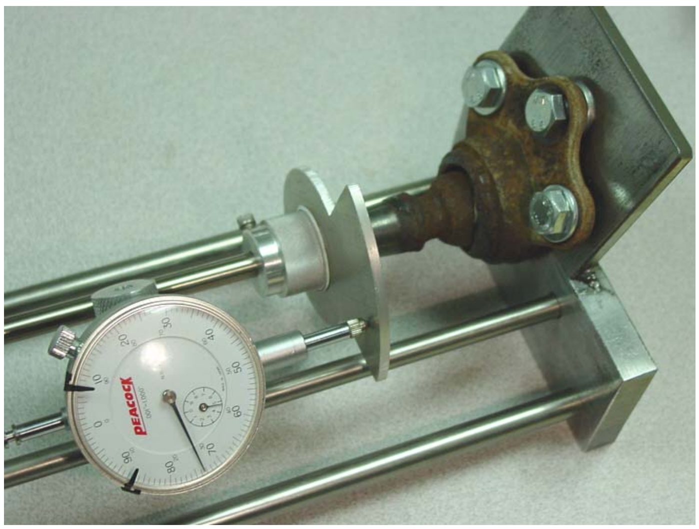


Figure 11. ODI end-play measuring fixture.

**DCC survey.** During EA03-023, DCC selected 78 vehicles in Southeastern Michigan "for a comprehensive review of the condition of the upper ball joints." Sixty-nine of the survey vehicles were from the subject vehicle population and two of these had already had both of the original upper ball joints replaced, resulting in 67 subject vehicles with at least one original equipment subject ball joint for evaluation.[8] There were 38 subject vehicles with NCM ball joints in the survey, 28 with four-wheel drive and 10 with two-wheel drive. These vehicles obviously had significantly less time-in-service than the TRW equipped vehicles. The TRW vehicles ranged in age from 4.5 to 7 years old, with all but 5 greater than 5 years old. The NCM vehicles ranged from 1 to 4.5 years old, with only 19 greater than 3 years old – including 14 target vehicles. When vehicles with less than 3 years and 30,000 miles are excluded from the analysis, there were only 17 vehicles with NCM ball joints, including 12 of the target vehicles.

Almost [redacted] of the 67 subject vehicles were determined by the DCC engineers to have upper ball joints requiring repair for excessive end-play or a boot anomaly.[9] A greater

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[8] Nine of the survey vehicles were built after the subject vehicle production range, when DCC indicated that upper ball joints with one-piece bearings had been implemented in production to address the water intrusion defect.

[9] The repair criteria in DCC's survey were either: (1) [redacted] or (2) [redacted]

percentage of the four-wheel drive vehicles [redacted] required repairs than two-wheel drive vehicles [redacted]. Almost [redacted] percent [redacted] of the NCM vehicles required upper ball joint repair, with more four-wheel drive vehicles [redacted] than two-wheel drive vehicles [redacted] needing service.

Survey joint wear data for original equipment ball joints are summarized in Table 12. Tables 13 and 14 show the respective data for vehicles above and below 50,000 miles in service. The data indicate that vehicles with four-wheel drive have greater upper ball joint wear in vehicles with at least 50,000 miles of service and that, in these vehicles, the upper ball joint wear is greater than the lower ball joint wear.

Approximately [redacted] of the four-wheel drive vehicles included in DCC's survey had at least one upper ball joint that had worn beyond the replacement specification of 0.060 inches of axial end-play. When the analysis is limited to four-wheel drive vehicles with at least 50,000 miles of service, the percentage of vehicles with out-of-specification upper ball joints increases to over [redacted]. Table 15 shows the number of vehicles with out-of-specification upper ball joints by drivetrain and model year. Tables 16 and 17 show the respective data for vehicles above and below 50,000 miles in service.

Tables 15-17 also indicate the number of such vehicles with at least one out-of-specification upper ball joint in which the DCC test engineers recorded an "audible noise" during an 8-mile test drive designed to model normal everyday driving conditions. Noise was detected in both of the vehicles with out-of-specification joints in the two-wheel drive vehicles, but was only detected in [redacted] of the [redacted] vehicles with out-of-specification joints in the four-wheel drive vehicles, including just [redacted] of [redacted] vehicles with joint wear exceeding 0.2 inches of end-play.

In the four-wheel drive vehicles, the DCC engineers were [redacted] as likely to detect noise in vehicles with less than half the specified replacement end-play as in vehicles with joints exceeding the specification (Table 5). When this analysis is limited to vehicles with greater than 0.2 inches of end-play in at least one upper ball joint, the engineers were able to detect noise just [redacted] of the time.[10]

| Maximum Ball Joint Wear (in.) | Noise Detected by DCC Engineers | | | |
|---|---|---|---|---|
| | Yes | | No | |
| | Vehicles | % | Vehicles | % |
| ≤ 0.030 | [redacted] | [redacted] | [redacted] | [redacted] |
| ≥ 0.060 | [redacted] | [redacted] | [redacted] | [redacted] |

Table 5. Noise detection in DCC survey, subject vehicles with four-wheel drive.

[10] All [redacted] vehicles with more than 0.2 inches end-play were high-mileage subject vehicles with four-wheel drive and TRW ball joints. While these vehicles are not in the target vehicle population, they share the same suspension design. DCC has provided no evidence showing that the noise from worn NCM joints is any different than the noise from similarly worn TRW joints in the subject vehicles (i.e., DCC has not claimed nor provided information showing that the NCM joints are noisier than the TRW joints when they wear to more than 0.2 inches end-play).

DCC's engineers also detected a number of upper ball joint boots with cracks, holes, folds, or other anomalies in survey vehicles. These conditions are distinct from the upper crimp integrity defect identified by DCC but can be equally harmful to joint sealing integrity. Over [redacted] of the subject vehicles surveyed exhibited such boot anomalies. Boot conditions were observed more frequently in the four-wheel drive vehicles [redacted] than in the two-wheel drive vehicles [redacted]. When the boot analysis is limited to NCM vehicles, the four-wheel drive vehicles [redacted] are again significantly higher than the two-wheel drive vehicles [redacted].

**<u>DCC'S POSITION</u>:** DCC contends that no safety defect exists in the subject vehicles. DCC believes that upper ball joint separation is possible only if lengthy and substantial warning is ignored. DCC also states that the loads required for separating even severely worn ball joints are much greater than the maximum loads that the joints can experience in service. DCC's model of the failure progression projects that joint wear must grow to more than [redacted] nches of axial end-play before separation is possible from even infrequent high tensile load events and that the joint will still have some retention capacity at more than [redacted] inches of end-play.

In addition, DCC has stated that the subject upper ball joints are compression type joints that are substantially different from tension type ball joints that have been the subject of prior safety recalls. In DCC's view, a compression ball joint design limits the possibility of separation to a low speed, rebound condition with a high degree of suspension articulation. According to DCC, testing found that these types of maneuvers develop the highest measured tensile loads at the upper ball joint, but only for very short durations. DCC stated that the load at the upper ball joint is virtually zero in all other steady state driving conditions, making separation of even a worn joint virtually impossible. Finally, DCC contends that, even in joints with compromised sealing integrity, degradation of the ball to socket interface occurs over an extended period of time and that the number of joint separations are minimal and do not reveal a trend or pattern.

**PE IR response.** In its September 5, 2003 response to PE03-032, DCC stated that the "substantial weight of the vehicle is continuously pressing against" the subject upper ball joints:

> **It is also important to note that the subject ball joint assemblies are "compression" type joints, meaning that the substantial weight of the vehicle is continuously pressing against these components. This design characteristic means that separation of the upper ball joint assembly is very improbable during normal and responsible operation of the vehicle.**

DCC identified 17 complaints responsive to ODI's PE information request that it had received through July 2003, including 4 "confirmed" and 6 "potential" upper ball joint separations.[11] All of the "confirmed" incidents and 4 of the "potential" incidents involved vehicles with NCM ball joints. This, and a disproportionate number of separation complaints involving NCM ball joints that were received by ODI after PE03-032 was opened, led ODI to upgrade the investigation to an Engineering Analysis. Almost all of the complaints involved four-wheel drive vehicles, but DCC indicated that the figures were proportional to

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[11] The PE request covered only the MY 1998 through 2002 Durango vehicles. All subsequent requests covered the full population of subject vehicles. The terms "confirmed" and "potential" are DCC's, as ODI believes that there were more potentially relevant complaints than cited by DCC.

the populations and there was no difference in separation rate between the four-wheel drive and two-wheel drive vehicles.

**Partial EA IR response.** In the March 12, 2004 response to EA03-023, DCC stated that: (1) the weight of the vehicle presses the subject joints together; and (2) that this is occurring constantly during vehicle operation so that separation is very improbable during normal operation of the vehicle:

> **First, the ball joint assemblies on the subject vehicles are "compression" type joints. Unlike "tension" ball joints, a compression ball joint assembly has the weight of the vehicle constantly pressing the ball joint assembly together. This design characteristic makes separation very improbable during the normal operation of the vehicle. In fact, separation has only been observed at lower speeds during extreme suspension travel.**

DCC identified 52 complaints responsive to ODI's EA information request that it received through early-February 2004, including 48 that involved vehicles with NCM ball joints. DCC indicated that 18 of the new complaints were "confirmed" and 7 were "potential" upper ball joint separations, all of which involved vehicles with NCM ball joints. This raised the total number of complaints from DCC to 69, with 60 involving NCM vehicles and only 9 involving the older TRW population. For the "confirmed" and "potential" incidents, the counts were 33 for the NCM vehicles and 2 for the TRW vehicles.

In addition, DCC classified 40 complaints provided by ODI with the information request, including 32 that did not duplicate incidents reported to DCC. Of the non-duplicative complaints, DCC classified 1 of the ODI complaints as "confirmed" and 13 as "potential" upper ball joint separations. The "confirmed" incident is the first and only such complaint involving a TRW ball joint, a MY 1999 Durango with 4-wheel drive. Ten of the "potential" incidents involved NCM vehicles, including 9 target vehicles.

**Supplemental EA IR response.** In a May 11, 2004 supplemental response to EA03-023, DCC repeated the claims concerning the suspension design and loading and also stated that: (1) there were "few complaints that alleged actual upper ball joint separation and those complaints did not reveal a trend or pattern;" (2) there was not a significant difference between the rate of separations in subject vehicles with NCM ball joints and those with TRW joints; (3) there is "substantial and significant warning to vehicle owners that the upper ball joints may need replacement well before an upper ball joint separation occurs;" (4) vehicle survey data showed that "any degradation of the ball to socket interface occurs over an extended period of time;" (5) test data showed that peak upper ball joint tensile loads were less than 25% of the tensile separation strength of a severely worn joint; (6) there were "dramatic spikes" in complaints following national media stories; and (7) there were no injuries.

**Complaint update.** In an e-mail submission on September 7, 2004, DCC provided ODI with a complaint update through late-July 2004. DCC's submission included 64 new complaints, with 56 involving vehicles equipped with NCM ball joints. The new complaints included 20 "confirmed" and 30 "potential" upper ball joint separations, with all 20 of the former and 25 of the latter involving vehicles with NCM ball joints.

In subsequent e-mail exchanges in September and October 2004, ODI sent DCC lists of complaints from its consumer complaint database that were potentially related to the alleged defect and DCC provided its assessment of the relevance of the complaints and any additional information it had concerning each incident. Excluding incidents already included in DCC's complaints or previously submitted with information request letters, ODI submitted 78 new complaints to DCC in these e-mails. DCC's assessment of the complaints identified no new "confirmed" and 4 new "potential" upper ball joint separations.[12] These "potential" incidents all involved NCM vehicles, including 2 target vehicles. DCC indicated that 46 of the ODI complaints contained insufficient information to count as upper ball joint separations, including 21 that alleged a wheel separation occurred. Twenty of these complaints involved target vehicles, including 15 of the wheel separation allegations.

| Category description | DCC complaints | | | | ODI complaints (with no matching DCC record)[13] | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | NCM 4x4 | NCM 4x2 | TRW 4x4 | TRW 4x2 | NCM 4x4 | NCM 4x2 | TRW 4x4 | TRW 4x2 | |
| Ball joint separation | 41 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 43 |
| Alleged ball joint separation – not confirmed | 28 | 8 | 7 | 0 | 11 | 3 | 3 | 0 | 60 |
| Alleged wheel separation – not confirmed | 10 | 1 | 4 | 1 | 7 | 1 | 3 | 1 | 28 |
| Wheel separation – due to preceding vehicle accident | 11 | 1 | 2 | 1 | 6 | 0 | 0 | 0 | 21 |
| Ball joint separation due to retaining nut shy | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 |
| Insufficient information available | 4 | 1 | 2 | 0 | 18 | 7 | 9 | 2 | 43 |
| Not related/Other | 4 | 4 | 0 | 0 | 10 | 6 | 5 | 3 | 32 |
| Total | 100 | 16 | 15 | 2 | 53 | 17 | 21 | 6 | 230 |

Table 6. DCC's complaint analysis.

Thus, by mid-October 2004, DCC had identified a total of 133 complaints from its records, with 116 (87 percent) involving the newer vehicles with NCM ball joints. Table 6 shows DCC's analysis of the complaints that it submitted in response to ODI's information requests during PE03-032 and EA03-023 for complaints relating to upper ball joint separation, wheel separation,

[12] Of the 110 ODI complaints submitted to DCC during EA03-023 that were not duplicative of DCC records, DCC classified only 18 as "confirmed" or "potential" upper ball joint separations. Of the 92 ODI complaints that DCC did not consider relevant, ODI would ultimately count 42 in its final analysis. These decisions were based largely on data collected from consumer contacts (e.g., witness statements, towing and repair records, photographs, and failed parts). ODI also counted another 19 complaints submitted up to November 30, 2004, that were not included in the submissions to DCC. These were either received after the e-mail exchange with DCC or were identified by ODI in subsequent database queries and consumer interviews.
[13] Does not include 13 complaints with unknown drivetrain – these were among those excluded from ODI's analysis.

or suspension collapse. When the ODI complaints are included, DCC had identified a total of 43 "confirmed" and 60 "potential" upper ball joint separations in the subject vehicle population.

Forty-two of DCC's "confirmed" and 50 of its "potential" complaints involved vehicles with NCM upper ball joints. These figures are overwhelmingly tilted toward the NCM vehicles, even before adjusting for the significant age bias in the TRW population. Eighty of the 92 incidents (87%) DCC classified as "confirmed" or "potential" upper ball joint separations in NCM vehicles involved the target population of four-wheel drive vehicles. Forty-one (95%) of the incidents DCC counts as "confirmed" involve target vehicles.

**Technical review meeting.** In June 2004, DCC presented a technical review of its analysis to ODI and VRTC staff.[14] DCC gave an updated presentation to senior NHTSA Enforcement staff in October 2004. In these technical reviews, DCC repeated its claim that the weight of the vehicle presses the subject ball joints together and indicated that the upper ball joint is in 30 lbs compression at curb. DCC states in this presentation that upper ball joint separations while driving are virtually impossible because, aside from short duration high-articulation rebound events at low speeds, the loads acting on the joints are virtually zero.

**Recall request response.** In a letter dated December 10, 2004, which followed ODI's recall request letter, DCC declined to conduct a safety recall of the target vehicles and provided three primary explanations for its decision: (1) the ball joint at issue does not contain a defect; (2) the performance of the ball joint does not present an unreasonable risk to motor vehicle safety; and (3) ODI's theory of safety defect is inconsistent with its own precedents and with applicable case law. For support, DCC states that:

- The target vehicles have a separation rate that is low in comparison to prior ball joint investigations that that were closed by ODI with no recall;
- There is no increasing trend in separations in the target population;
- ODI counted incidents that did not allege an upper ball joint separation;
- The performance of the ball joint does not present an unreasonable risk to motor vehicle safety;
- That ball joints are subject to wear and that worn joints should not be termed "failures;"
- That ODI mischaracterized DCC's survey results;
- That ODI's recall request letter "reflects a fundamental unfamiliarity with the design and operation of a compression type upper ball joint;"
- That ODI's letter contained "numerous factual errors and mischaracterizations of the record;" and
- That ODI could not "bear its burden to prove a safety-related defect in the [target] vehicles."

DCC also reiterated its belief that the upper ball joints are compression type joints that constantly bear the weight of the vehicle. DCC attributed the incidents of ball joint separation in the subject vehicles to owner neglect and suggested the failures were caused by "expected wear and tear."

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[14] "AN/DN Front Suspension Upper Ball Joint, PE03-032/EA03-023," NHTSA Quarterly Review, June 10, 2004.

**<u>ODI ANALYSIS</u>:** ODI disagrees with DCC's position.

ODI's analysis of the data gathered in this investigation shows evidence of a safety-related defect in the target vehicle population. The separation rate in the target vehicles is very high when compared to: (1) the other segments of the subject vehicle population that also contained the joint integrity defect resulting in premature wear; and (2) each of the vehicle populations in the peer investigations cited by DCC that were not subject to safety recall.

The fundamental premise of the DCC letters is that the separation rate in the target population is lower than in certain peer investigations – an analysis that is inaccurate. For example, DCC claims that the target vehicle separation rate is similar to that recorded for the vehicles investigated for lower ball joint separation in RQ03-002[15] when the actual comparison at 60 months in service shows the target vehicle rate to be over four times higher. Regarding DCC's assertions that suspension design characteristics and audible warning sufficiently mitigate the risks of joint separation in the subject vehicles, the separation data are the only valid measure of: (a) the improbability of joint separation due to suspension design; and (b) the adequacy of warning in alerting users to failing components before they result in separations that cause hazards to vehicle occupants and surrounding traffic and pedestrians.

**Separation counts.** In its December 10, 2004 letter, DCC stated that it "vigorously disputes" the number of separations that ODI is using to calculate failure rates and trends in the subject vehicles and suggests that ODI is counting incidents where no separation is alleged to have occurred. ODI disagrees. ODI's complaint counts are conservative and factored additional information collected by ODI to validate separation incidents. Limiting the analyses to DCC's complaint counts reveals the same patterns and trends.

ODI's complaint counts are conservative. ODI did *<u>not</u>* include any incidents that were categorized by DCC as resulting from impact damage or retention nut torque, even though in some of the incidents the information was ambiguous. ODI also excluded incidents alleging lower ball joint separation or other front suspension failures, unless subsequent investigation determined that a worn upper ball joint was the actual cause.[16] Nor did ODI include six complaints alleging that an upper ball joint separated while the vehicle was being lifted to perform service to the tire or suspension, though these events do provide additional evidence of the advanced wear that the subject joints are reaching in service.[17]

The ball joints shown in Figures 3c, 6a, 20 and 22 are examples of parts that were discounted by DCC because the complaint did not contain sufficient information. ODI was able to validate these incidents by contacting the consumers and collecting additional information, which in these cases *<u>included the failed parts</u>*. DCC discounted 71 complaints because they contained insufficient information, including at least 28 alleging incidents of wheel separation. Forty-three of these complaints involved target vehicles, including 17 of the wheel separations.

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[15] MY 1995-97 Ford Crown Victoria, Mercury Grand Marquis, and Lincoln Town Car lower ball joint separation.
[16] DCC has indicated to ODI that it has not confirmed <u>any</u> lower ball joint separations in the subject vehicles – another benchmark for the high upper ball joint separation rates in the target vehicles.
[17] ODI is already aware of at least one incident of joint separation during service for a vehicle receiving repairs under Recall 04V-596 in the Washington, DC metropolitan area.

Moreover, the same patterns and trends evident in analyses using ODI's complaint counts can also be discerned in analyses using only the complaints that DCC considers relevant using its more restrictive criteria. Table 7 provides a breakdown of the separation report data by the four major vehicle groups in the subject vehicle population. ODI conducted each of the analyses concerning separation rates and trends in the subject vehicles with both ODI's and DCC's complaint counts. The analyses showed similar results with each set of data.

| Subject Vehicle Group | | | DCC Separation Counts | | | | ODI Separation Counts | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ball Joint** | **Drive** | **Volume** | **Rpts** | **Crash**[18] | **Inj**[18] | **Rate at 60 MIS** | **Rpts** | **Crash** | **Inj** | **Rate at 60 MIS** |
| NCM | 4x4 | 591,996 | 80 | 6 | 3 | 39.2 | 120 | 12 | 4 | 41.9 |
| | 4x2 | 454,137 | 12 | 0 | 0 | 5.1 | 21 | 0 | 0 | 7.0 |
| TRW | 4x4 | 420,373 | 11 | 1 | 0 | 1.4 | 21 | 1 | 0 | 2.1 |
| | 4x2 | 322,028 | 0 | 0 | 0 | 0.0 | 2 | 0 | 0 | 0.3 |

Table 7. Separation data summary by subject vehicle group.

**Separation rate.** Analysis of the separation data shows that after about 48 months in service the rate in the target vehicles is high in comparison to the other subject vehicles and all of the non-recalled vehicles from the peer investigations cited by DCC. The target vehicle separation rate at 60 months in service is at least 6 times higher than the other groups of subject vehicles and is also much higher than any of the non-recalled peer vehicles. These data clearly show that DCC is wrong in its characterizations of the subject vehicle separation rates and how they compare with prior ODI investigations of front suspension ball joint separation.

Figure 12 shows the cumulative failure (separation) frequency curves for each of the four groups of subject vehicles through November 2004. This analysis is based on the ages of the various populations at the end of November 2004 and is, therefore, a low estimate, since the DCC data was last updated through late-July 2004. For service life *t*, the cumulative failure rate, *F(t)*, is calculated by summing the incremental rate increase at that service interval with the rates from the prior intervals:

$$F(t) = \sum_{i=1}^{t} 100{,}000 \times (f_i / n_i)$$

The rate increase at each service interval is calculated from the number of separations in that interval ($f_i$) and the number of total units that have reached that service interval (i.e., units which had an opportunity to fail at that interval – $n_i$).

[18] Although DCC contends that there have been no confirmed multi-vehicle crashes or injuries associated with the alleged defect, 2 of the 3 incidents in which multi-vehicle crashes and injuries have been alleged involve incidents that DCC has classified as "confirmed" upper ball joint separations.

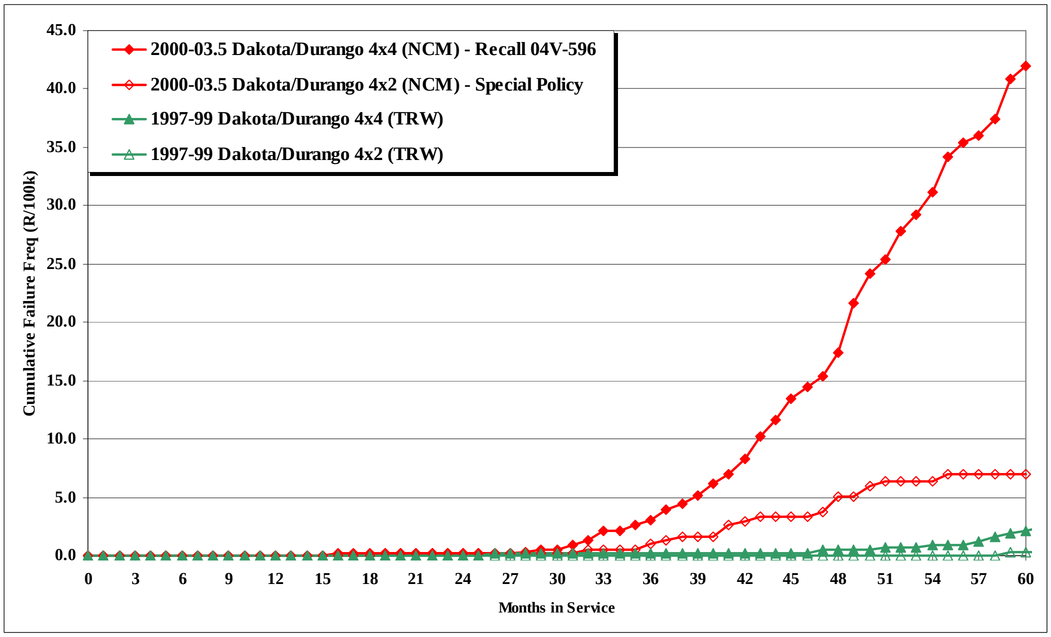


Figure 12. Cumulative failure frequency plot, subject vehicles.

The data show that the separation rate in the target vehicles begins to climb after about 30 months in service, is nearly 4 times greater than the NCM two-wheel drive vehicles at 48 months in service, and is over 6 times greater than those vehicles at 60 months. Beginning at about 33 months the target vehicle separation rate exceeds all of the TRW vehicles by more an order of magnitude and by 60 months is more than 20 times greater than the TRW four-wheel drive vehicles and over 100 times greater than the TRW two-wheel drive vehicles.

The target vehicles also show significantly greater separation rates than the peer vehicles from prior ODI front suspension ball joint investigations cited by DCC in its correspondence and technical review presentations to NHTSA. ODI analyzed the peer data to exclude complaints that did not involve separations or were clearly not related to the joint under investigation. However, separation allegations where the joint (i.e., upper or lower ball joint) was *unknown* were counted – less stringent criteria than has been applied in analyzing the data for the subject vehicles (i.e., the counts were more inclusive for the peer vehicles).

Figure 23 shows the separation rate plots for the vehicles investigated in RQ02-012[19] and RQ03-002. The data show that those populations are not similar to the target vehicles, as claimed by DCC, but instead are similar to the NCM two-wheel drive vehicles at 48 and 60 months in service. As previously noted, the target vehicles are more than four times greater than the RQ03-002 vehicles at 60 months and over eight times greater than the RQ02-012 vehicles at the same age.

Figure 25 shows the comparison of the subject vehicles with vehicles investigated in EA99-022 for upper and lower ball joint separation, which resulted in a recall of some vehicles and a special policy to extend warranty coverage in additional vehicles. After 48 months in service,

[19] MY 1998-2000 GM T-Utility upper ball joint separation.

the separation rate for the target vehicles exceeds all of the peer populations that were not subjected to recall remedy. At 60 months in service the target vehicle rate is double that of the closest non-recalled population.

Figures 24 and 25 repeat the analyses, using only the complaints that DCC considers relevant. Because the DCC complaint data is last updated through late-July 2004, all analyses using just the DCC counts are based on the ages of the subject vehicle populations at the end of July 2004. This results in cumulative failure frequency curves that are very similar to those calculated using ODI's complaint counts.

DCC's statistical comparisons of the subject vehicles with vehicles from peer investigations have mischaracterized the relative failure rates by: (1) excluding relevant separations from the subject vehicle counts; (2) including irrelevant separations in the peer vehicle counts; and (3) failing to account for vehicle age by comparing peer populations that have all surpassed 60 months in service with the target population, where less than 10 percent of the target vehicles have reached that age.

**Separation trend.** ODI's analysis of the separation trends found that the target vehicles have the highest rate of increase over the period from 48 to 60 months in service of any of the subject and peer vehicles studied, including the recall population from EA99-022 (Recall 01V-200). The trend analysis is at least as significant as the failure rate analysis, since it provides the best information about future risk. Trend analysis indicates whether the separations are decreasing, remaining constant, or increasing as a function of time in service. The target vehicles clearly show an increasing rate.

Figures 27 and 28 show the target vehicle trend lines for the age intervals from 24 to 36, 36 to 48, and 48 to 60 months in service using the ODI and DCC complaint counts respectively. Both curves show distinct accelerating separation rates as the vehicles advance in age. Figure 29 compares the increases in separation rates over those periods for the subject vehicles and the peer investigations. These figures are the best indicators of the future separation experience that is likely to occur in the target vehicles. The data show that the target vehicles have the most obvious pattern of trend increase and the highest rate of increase from 48 to 60 months of all of the vehicle groups analyzed, including the vehicles recalled in 01V-200 (GM T-Utility). Using only DCC's data reveals a similar trend (Figure 30).

DCC does not agree that there is an increasing trend of separations in the target vehicles. DCC contends that "when the incidents are analyzed by the month when the separation occurred, and the mileage at the time, there is no pattern – it is a random scatter diagram." ODI does not consider DCC's approach for assessing failure trends to be sufficient. This approach merely shows the distribution of mileage accumulation over time for the incident vehicles. The data is concentrated around a mileage accumulation rate of a little over 15,000 miles/year using either ODI or DCC counts, which is about the same as a sample from the overall fleet as shown in Figures 31 and 32.

ODI notes that the failure mechanism in the subject components is governed by both time (corrosion) and mileage (wear), so vehicles with low annual mileage accumulations (due to greater corrosion effects) and vehicles that accumulate miles rapidly (due to wear effects) are both included among incident vehicles (i.e., the incidents are not concentrated either in vehicles with greater than normal mileage accumulation rates or in those with less than normal rates).

**Safety consequences.** According to DCC, the defective upper ball joints in the target vehicles do not represent an unreasonable risk to motor vehicle safety. ODI disagrees. All of the separation incidents result in a loss of vehicle steering control and a disabled vehicle. Many incidents also allege that the wheel assembly completely separated from the vehicle, sometimes with the vehicle traveling at speeds of 45 mph or more. Wheel separation incidents create hazards for the incident vehicle occupants from the loss of steering and braking control that result, and there is also a safety risk to surrounding traffic and pedestrians.

Figure 13. MY 2000 Durango 4x4 - 60,000 miles – 45 mph (DCC count = YES).

Contrary to DCC's claims, separation incidents have not been limited to "low speed, high articulation events" (Figure 13). Many of the separations have been reported at speeds greater than 30 mph, often just after the vehicle crests a rise in the road. In these incidents the separation frequently results in a complete separation of the affected wheel, steering knuckle, brake components, and half-shaft. ODI has identified 58 allegations of wheel separation, including 48 in the target vehicles.

In one incident involving a MY 2000 Durango, for example, the separated wheel struck a vehicle in the opposing lanes of traffic. Drivers traveling at posted speeds of 45 to 60 mph have also reported losing steering control and crossing into oncoming traffic. There are 27 wheel separations among the incidents DCC has classified as "confirmed" or "potential" upper ball joint separations, with 23 of these occurring in the target vehicles. If the analysis is limited to just the DCC "confirmed" incidents, there are 14 wheel separations in total and 13 in the target vehicles. The latter group includes incidents that were at speeds of 45 miles per hour or more.

Table 8 lists five target vehicle incidents that reportedly occurred at speeds of 45 miles per hour or more. Two of these incidents are among those DCC counts as "confirmed." ODI has obtained and analyzed the ball joints from those and two others (see Referenced Figures).

| VOQ No. | Mileage | Speed | DCC confirm | Ball joint | Description |
|---|---|---|---|---|---|
| 10073140 | 49,000 | 60 | | | Right upper ball joint separated at 60 mph. Wheel separated and truck spun across 3 lanes of traffic. |
| 10057080 | 27,900 | 55 | | Fig 20 | Right upper ball joint separated at 55 mph. Lost control and swerved wildly into oncoming traffic. |
| 10052051 | 79,300 | 50 | ✓ | Fig 6b | Right upper ball joint separated at 50 mph. Able to regain control and avoid a collision. |
| 10059031 | 60,000 | 45 | ✓ | Fig 21 | Right upper ball joint separated at 45 mph. Wheel separated and vehicle lost control and landed in a ditch. |
| 10082102 | 50,002 | 45 | | Fig 6a | Left upper ball joint separated at 45 mph. Heard a loud bang and saw wheel roll across the road. Vehicle skidded across the road into a ditch. |

Table 8. Target vehicle upper ball joint separations at speeds of 45 mph or greater.

**Owner neglect.** DCC contends that separation of the subject ball joint "is not likely except in cases of lack of proper vehicle maintenance and intentional disregard for the clear and present warning provided." ODI disagrees. The DCC survey vehicle evaluations and the VRTC noise evaluation both demonstrate that the noise produced by worn joints may not be audible to vehicle occupants. The field data show high and increasing separation trends in the target vehicles, which is the most valid measure of the adequacy of warning symptoms.

Most of the consumers interviewed by ODI reported that they did not hear any noise prior to the separation incident. Several of these owners, in spite of their awareness of the issue through media reports and word-of-mouth, indicated that they still did not detect anything unusual prior to a wheel separation failure. For example, one informed owner made inquiries at a local Chrysler dealer, learned that there was no recall, and operated the vehicle more cautiously before experiencing a separation that disabled the vehicle in front of oncoming traffic. The driver heard no noises prior to the failure.

In DCC's view, "ODI's reliance on the consumer responses to interviews is not persuasive." ODI disagrees and notes that, in addition to the VRTC noise evaluation, DCC's own analysis, as discussed above, highlighted the difficulty in detecting noise from a worn upper ball joint in the subject vehicles.

**Recall history.** Most of the recalls for front suspension ball joints have been conducted to address defects resulting in excessive/premature joint wear. The most common root cause in these recalls is compromised sealing in maintenance-free ball joints, usually involving the boot. The basic elements of the recalls are: (1) compromised joint integrity allowing an entry path for water and dirt; (2) loss of joint lubrication; (3) excessive wear which, in extreme cases, could result in joint separation; and (4) joint separation results in loss of vehicle control which increases the risk of a crash. All of these elements are present in the NCM joints used in the target vehicles.

Table 9 lists the recalls that have been conducted over the last 10 years to address front suspension ball joint separation defects related to excessive wear. Most of the recalls have involved lower tension-type ball joints in which wear can proceed more rapidly in a joint with no lubrication. In comparison, upper ball joint separation is unusual as shown by the subject vehicles with TRW joints, which have had relatively few separations even with joint integrity concerns. That the target vehicles have had the separation experience they have further points to the poor retention characteristics of the NCM joints relative to their TRW peers and upper ball joints used in other peer vehicles.

| Recall | 573 date | Mfr | Vehicle volume | Seps[20] | Joint type | Defect Type | ODI Inv |
|---|---|---|---|---|---|---|---|
| 95V-032 | Mar-95 | Toyota | 27,604 | 0 | Lower – tension | Inadequate lubrication | |
| 97V-201 | Nov-97 | DCC | 599,000 | 30 | Lower – tension | Loss of lubrication | EA97-016 |
| 98V-322 | Dec-98 | Ford | 175,000 | 45 | Lower – tension | Bearing overload | PE98-045 |
| 99V-066 | Apr-99 | DCC/ Mitsubishi | 474,588 | 62 | Lower – tension | Loss of lubrication | PE99-008 |
| 99V-069 | Apr-99 | Honda | 125,380 | 0 | Lower – tension | Ball surface finish | |
| 99V-125 | May-99 | Toyota | 2,737 | 0 | Lower – tension | Inadequate lubrication | |
| 00V-421 | Nov-00 | DCC/ Mitsubishi | 961,228 | 120 | Lower – tension | Loss of lubrication | RQ00-015 |
| 01V-200 | Jun-01 | GM | 48,600 | 28 | Upper – stabilizer | Loss of lubrication | EA99-022 |
| 03V-034 | Feb-03 | DCC | 11,698 | 9 | Lower – tension | Loss of lubrication | EA02-033 |
| 03V-328 | Sep-03 | GM | 41,477 | 0 | Lower – tension | Loss of lubrication | |
| 03V-460 | Nov-03 | DCC | 336,000 | 9 | Lower – tension | Loss of lubrication | |
| **04V-596** | **Dec-04** | **DCC** | **591,996** | **120** | **Upper – stabilizer** | **Loss of lubrication** | **EA03-023** |

Table 9. Recalls for front suspension ball joint separation due to premature wear-out.

DCC's complaint that ODI has inappropriately mixed upper ball joint investigations and lower ball joint investigations is incorrect. ODI notes that it was DCC that first compared the subject vehicle failure experience with a lower ball joint investigation when it incorrectly stated that the target vehicle failure rate was lower than that of vehicles ODI investigated for a lower ball joint concern in RQ03-002. ODI does agree that such comparisons are appropriate, since once a separation has occurred the consequences are similar – at a minimum, a collapse of the front suspension at the affected wheel with a loss of steering control.

DCC states that the lower ball joint recalls were conducted to address "some design or manufacturing flaw contributing to the risk of separations"[21] and that no such flaws have been identified in the subject vehicles. This is incorrect. The reasons for the premature wear in the

[20] Separation data for 97V-201 and 99V-066 are for only a portion of the recall populations.
[21] This statement is incorrect. Recall 00V-421, which included about 390,000 DaimlerChrysler vehicles, was initiated to address a defect involving premature wear "as a result of currently unknown reasons."

subject upper ball joints are known and a new joint has been developed with multiple design and manufacturing countermeasures to address those flaws.

**Alleged defect.** As previously described in this report, the alleged defect is upper ball joint separation. This has been a result of premature wear-out due to compromised joint integrity at the crimp and boot. This permits contaminants (e.g., water, sand, salt, dirt) to enter the joints, evacuate the lubricant and contribute to abrasive wear of the ball and socket. Conditions that permit such contaminants to penetrate permanently sealed joints "will in most cases drastically reduce the useful life of a ball and socket joint."[22] Conditions affecting joint sealing at the upper crimp and the boot have both been identified in the subject components. A design change implemented by DCC to improve joint integrity determined the scope of this investigation and of ODI's recall request of the target vehicle population.

DCC argues in its December 10 letter that parts replaced for "durability concerns" should not be termed failures:

> **In its letter, ODI loosely uses the term "failure" to describe durability concerns with the upper control arm ball joint assemblies. This is a serious misapplication of the term. As ODI describes, leakage through the crimp seal may lead to looseness and noise from the upper ball joints, but this is not a "failure" in the context of joint separation as is suggested in the letter. While ball joint separation is not a desired outcome, we** [DCC] **have shown in this case that ball joint separation will not occur if the car is reasonably maintained. Moreover, ODI has not attempted to correlate crimp seal issues with the separations that have occurred in the field.**

This is incorrect. As described at the beginning of this report, the inadequate crimp seal is the primary cause of the compromised joint integrity that results in loss of lubrication followed by premature failures of the subject components. This is the failure mechanism responsible for the joint "durability concerns" and the joint separation incidents in the target vehicles. It is also the typical mechanism for service failures of ball joint assemblies with "irregular and inefficient lubrication:"[23]

> **Typical service breakdown of a ball joint bearing is component wear resulting in noise and end-play or looseness and hysteresis in the control system or <u>*rupture and breakage of some component. The main cause of ball joint premature malfunction is irregular and inefficient lubrication*</u>.** (emphasis added).

Loss of lubrication resulting from compromised joint integrity is the cause of the failure mechanism affecting the subject components and for the majority of lower ball joint safety recalls as previously discussed in this report.

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[22] Bordon W., Zucchini M. and Simião G.; "High Performance Ball Joint;" SAE Paper No. 2003-01-3668, November 2003.
[23] Shuster M., Maughan G. and Arnold R.; "Development of a Maintenance Free Self-Lubricating Ball Joint;" SAE Paper No. 1999-01-0036, March 1999.

**Age and wear.** DCC contends that the subject components do not contain a defect. DCC argues that components that fail because of "age and wear" cannot be considered defective. ODI disagrees. While the subject component failures are related to "age and wear," the presence of these two factors does not preclude the existence of a defect. In fact, most defects in mechanical components involve age and wear and the term "wear-out" is generally understood to be that portion of a component's service life that exhibits accelerating failure rates. The question, therefore, is whether the subject component failures are due to "expected wear and tear" as DCC contends, or are occurring prematurely.

Citing *United States v. General Motors Corporation (Wheels)*, 518 F.2d 420, 435-436 (D.C. Cir. 1975), DCC argues that because the ball joint separations are failing because of "age and wear," they cannot be termed defective. DCC quotes from the *Wheels* court:

> **"It would appear economically, if not technologically, infeasible for manufacturers to use tires that do not wear out, lights that never burn out, and brakes that do not need adjusting or relining.** ***Such parts cannot be reasonably termed defective if they fail because of age and wear*****."** ***Wheels*****, 518 F.2d at 536. (**[DCC's] **emphasis added).**

This statement does not apply to the subject ball joints. This investigation involves ball joint separations at relatively low mileages. Analysis of the extraordinarily high complaint, warranty, and part sales data all show that the NCM ball joints begin to "wear-out" well within one-tenth of their design life. Analysis of parts from warranty returns and complaint vehicles show that these failures are caused by the inadequate joint integrity described in this report that result in loss of lubrication followed by corrosive/grinding wear of the ball and socket. Analysis of parts from survey vehicles shows that these conditions are prevalent in the subject vehicle population. The data show that catastrophic separation failures caused by such premature wear-out begin to occur within one-fifth of the design life of the subject components.

ODI also notes that the majority of the lower tension-type ball joint separation recalls were performed to address defects involving excessive/premature wear, not unlike other defect investigations and recalls that addressed problems involving "age and wear" (e.g., fatigue failures, compressive stress relaxation in rubber hoses and o-rings, tire tread separations, abrasive failures of tubes carrying combustible fluids, and electrical switches that catch fire after thousands of cycles).

Finally, it is incorrect to suggest that the subject component failures are related to "expected wear and tear" or comparable to "tires that wear out, lights that burn out and brakes that need adjusting or relining." ODI emphasizes that when safety-related defects have been identified in tires, lights, or brakes; ODI has pursued – and manufacturers have voluntarily initiated – recalls providing appropriate remedies for those systems. Analyses of the available field and technical data show that the subject components are defective and that the parts DCC is using to replace them in Recall 04V-459 have incorporated substantial changes in design and manufacture to address those flaws.

**Publicity.** DCC contends that the separation data is biased against the subject vehicles because of the publicity that the defect condition has received. ODI disagrees. ODI notes that while the publicity applied to all of the subject vehicles, only the target population has shown the high separation rate and trend detailed in this report. The fact that four-wheel drive versions of the Dakota and Durango showed higher separation rates led NHTSA to narrow its focus to this population of vehicles.

DCC notes that there were large increases in complaints after the investigation was opened corresponding with news media coverage. The largest percentage increase occurred immediately after PE03-032 was opened and received press coverage that typically occurs when a defect investigation is opened by ODI. ODI notes that each of the subject and peer investigation vehicles received similar publicity, and the subject vehicles all received the same level of publicity. The fundamental premise of DCC's concern regarding publicity is that all vehicles have upper ball joints that are corroding and experiencing premature wear-out, but because of publicity the problems are reported more frequently in the subject vehicles. The VRTC survey shows that this is not true of the peer populations, which showed no wear in vehicles with less than 100,000 miles service.

A simple analysis of DCC's own complaint data in the period before August 2003 and the two six month periods that followed, both of which would have been influenced by any publicity effect, shows a clearly increasing trend in the target vehicles and no trends in the other segments of the subject vehicle population (Figure 14).

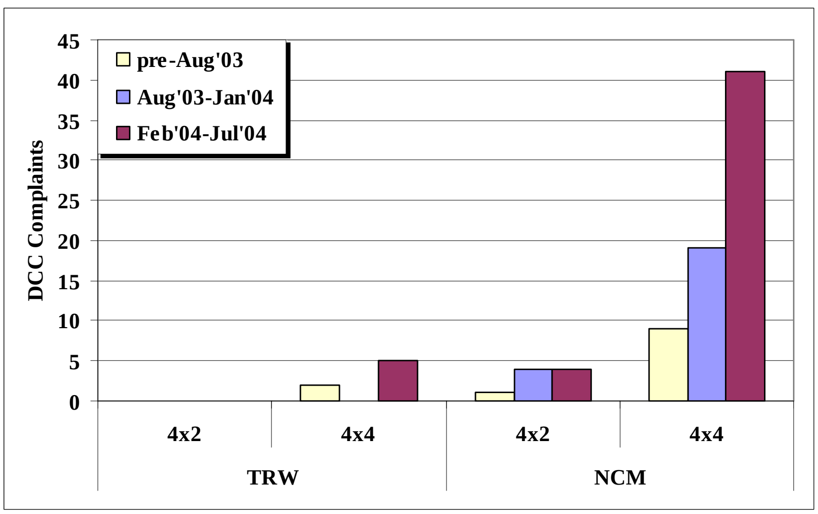


Figure 14. Complaint trends – DCC "confirmed" or "potential"
upper ball joint separations by reporting period (does not include ODI complaints).

Finally, while DCC insists that adverse publicity played a role in providing a biased view of the number of complaints received from the public, ODI disagrees. Citing *United States v. General Motors (X-Cars)*, 841 F.2d 400 (D.C. Cir. 1988), DCC argues that the complaint data relied on by ODI is tainted by the impact of media publicity. ODI notes that the *X-Cars* court indicated that the adverse publicity in that case played a role due in large part to the agency's release of a film allegedly showing the impact of rear wheel lock-up on driver control. In contrast, the condition at issue in this case stems from a part that prematurely fails in a dramatic and verifiable fashion. Accordingly, publicity's role in this case, if any, is driven by a verifiable event (wheel separation) that a complainant has either experienced or not experienced and does not depend on driver perception, as was the case in *X-Cars*.

**Suspension design.** DCC contends that the subject upper ball joints are compression type joints that are substantially different from tension type joints that have been the subject of prior safety recalls by the company. DCC stated that this design characteristic limits the possibility of a separation to low speed, high suspension articulation events because they produce the greatest tensile loads at the upper ball joint. According to DCC, the loads at the upper joint are "virtually zero" in all other steady state driving conditions – making separation while driving "virtually impossible." DCC's analysis does not explain the many incidents that have occurred in the target vehicles that did not involve a "low speed, high suspension articulation event."

While it is true that the subject joints are substantially different from lower tension-type joints and <u>*should*</u> be far less likely to experience joint separations within the life of the vehicle, it is not true that the possibility of separation is limited to low speed, high articulation events. Wear that reduces the retention capacity of the NCM joints is not limited to tensile load events, but also occurs under lateral and longitudinal loading. As previously stated in this report, separated ball joints analyzed by ODI and VRTC had no retention capacity remaining and could have separated with virtually no load during any event causing relative vertical motion between the upper control arm and knuckle. Such motion is not limited to low speed, high articulation events.

The subject ball joints are not constantly pressed together by the weight of the vehicle, as DCC has claimed. Nor is it true that DCC's test data shows that "the only condition in which an upper ball joint will experience a tensile load is during a significant rebound event such as a wheel dropping below the curb plane, and then only for a very short duration of time." For example, the loads experienced when cornering and during low speed turning maneuvers involve tensile loads that can contribute to wear and are frequently occurring events. In addition, joint wear is a product of all of the loads acting on the joint and the subject joints have worn sufficiently to separate while driving in vehicles with less than 30,000 miles of service. With regard to the classification of the subject components, ODI notes that DCC Truck Chassis Engineering identifies the joint type as [redacted] in a February 6, 2004 design review document furnished in response to EA03-023.

Finally, the only relevant questions regarding the suspension load characteristics are:
(1) whether an upper ball joint with compromised sealing will experience premature wear-out;
(2) whether joints that experience such premature wear-out can separate while driving during conditions that present a safety risk to the vehicle occupants and others; and (3) whether a *non-diminimis* number of such separations have occurred. All of these are true of the target vehicles.

[24] "AN/DN Upper Ball Joint Design Review and Manufacturing Status," DCC Truck Chassis Engineering, February 6, 2004 (Enclosure 23 to March 15, 2004 confidential response to EA03-023).

**CONCLUSIONS:**

1. The upper roll crimps in the subject ball joints do not adequately prevent water and other contaminants from entering the permanently sealed, "lubed-for-life" joints. This results in loss of lubrication and accelerated, premature wear-out.

2. Survey and warranty return data also show high percentages of boot anomalies in subject ball joints that can permit water and dirt to enter the joints and contribute to premature wear-out.

3. DCC has implemented several design and manufacturing changes to address problems with compromised integrity and resultant premature wear-out in the subject ball joints.

4. The NCM joints permit an increased risk of separation when their integrity has been compromised.

5. DCC's service part for Recall 04V-596 was specifically developed to incorporate design countermeasures for both the joint integrity and ball retention concerns in the subject upper ball joints.

6. The separation rate in the target population at 60 months in service is 41.9 incidents per 100,000 vehicles, which exceeds that of the other groups of subject vehicles and all other vehicles investigated by ODI for front suspension ball joint separations that were not recalled.

7. The rate of increase in the separation rate in the target population at 60 months in service – 24.5 incidents per 100,000 vehicles per year in service – exceeds that of the other groups of subject vehicles and all other vehicles from the peer investigations cited by DCC, including those recalled in 01V-200 (EA99-022).

8. Although DCC's analysis fails to count many relevant incidents, the patterns and rankings in the separation rate and trend analyses using the ODI complaint counts are also evident when using the DCC complaint counts.

9. Separation incidents have been alleged at speeds up to 60 miles per hour. Several have allegedly caused the incident vehicle to lose control and cross oncoming lanes of traffic.

10. Upper ball joint separations have resulted in 58 alleged wheel separations, including 48 in the target vehicles. In at least one incident, the separated wheel struck another vehicle.

11. [redacted] percent of the target vehicles in the DCC survey were judged by DCC engineers to require repairs for joint wear or problems with the boots.

12. DCC's engineers did not detect noise in [redacted] percent of the four-wheel drive subject vehicles in the DCC survey with upper joints worn beyond the service replacement specification. For four-wheel drive vehicles in the DCC survey, the DCC engineers were more likely to detect noise in vehicles with good ball joints as they were in vehicles with bad ball joints.

13. The VRTC survey found that loose upper ball joints were common in subject vehicles but non-existent in peers with 100,000 miles or less of service.

14. Analysis of separated parts indicates that retention force is lost in the NCM ball joints when wear has progressed to levels corresponding to about 0.45 to 0.50 inches axial end-play.

15. Complaint, warranty, and part sales data also show a premature wear-out problem in the two-wheel drive vehicles equipped with NCM ball joints, which have the ball retention concerns when worn. However the separation data for the NCM two-wheel drive vehicles is similar to the rates of vehicles that ODI has investigated for ball joint separation and closed with no field action. DCC has provided these vehicles with a special policy that extends warranty coverage for the upper ball joints to 10 years/100,000 miles.

16. Complaint, warranty, part sales and survey data all indicate that premature wear-out of the upper ball joint is a problem in the subject vehicles with TRW ball joints. However, the incidence of upper ball joint separation has been low in the TRW equipped vehicles. DCC has taken no field action to address the wear concerns in these vehicles.

17. The factual evidence presented to and discovered by ODI does not support DCC’s claims of inaccuracies in ODI’s recall request letter.

**REASON FOR CLOSING:** DCC is recalling the target population of approximately 600,000 MY 2000 through 2003 Durango and Dakota vehicles with four-wheel drive to replace the front suspension upper ball joints with redesigned parts that do not have the joint integrity concerns and have substantially improved joint retention capacity (NHTSA Recall No. 04V-596). Though DCC does not admit to a safety-defect in the subject components, ODI believes that the facts in this investigation show otherwise.

Because of the low rates of separation incidents in the remaining subject vehicles, a safety-related defect has not been identified in those populations and further use of agency resources does not appear to be warranted. The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists in those vehicles. The agency reserves the right to take further action if warranted by the circumstances.

Safety Defects Engineer — 2/11/05 Date

I Concur:

Chief, Vehicle Control Division — 2/11/05 Date

Director, Office of Defects Investigation — 2-11-05 Date

## List of Tables

| Ball Joint | MY | DCC Complaints (through 1/14/04) | | | | | | ODI Complaints (through 2/5/05) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dakota | | Durango | | Total | | Dakota | | Durango | | Total | |
| | | Rpts | R/100k | Rpts | R/100k | Rpts | R/100k | Rpts | R/100k | Rpts | R/100k | Rpts | R/100k |
| TRW | 1997 | 293 | *227.6* | -- | -- | 293 | *227.6* | 88 | *68.4* | -- | -- | 88 | *68.4* |
| | 1998 | 258 | *169.3* | 455 | *369.7* | 713 | *258.8* | 146 | *95.8* | 408 | *331.5* | 554 | *201.1* |
| | 1999 | 342 | *254.9* | 828 | *405.9* | 1,170 | *346.0* | 206 | *153.6* | 794 | *389.2* | 1,000 | *295.7* |
| | Total | 893 | *215.0* | 1,283 | *392.3* | 2,176 | *293.1* | 440 | *105.9* | 1,202 | *367.5* | 1,642 | *221.2* |
| NCM | 2000 | 227 | *121.4* | 325 | *166.1* | 552 | *144.3* | 213 | *114.0* | 345 | *176.3* | 558 | *145.8* |
| | 2001 | 132 | *83.2* | 140 | *101.9* | 272 | *91.9* | 158 | *99.6* | 162 | *117.9* | 320 | *108.1* |
| | 2002 | 85 | *58.5* | 56 | *49.9* | 141 | *54.8* | 158 | *108.8* | 70 | *62.4* | 228 | *88.5* |
| | 2003 | 15 | *25.5* | 11 | *21.6* | 26 | *23.7* | 36 | *32.6* | 26 | *21.3* | 62 | *26.6* |
| | Total | 459 | *83.5* | 532 | *107.2* | 991 | *94.7* | 565 | *93.9* | 603 | *106.2* | 1,168 | *99.9* |
| Total | | 1,352 | *140.1* | 1,815 | *220.4* | 3,167 | *177.1* | 1,005 | *98.8* | 1,805 | *201.7* | 2,810 | *147.0* |

Table 10. DCC and ODI total complaints, upper ball joints.[25]

| Model Year | Two-Wheel Drive | | | | Four-Wheel Drive | | | |
|---|---|---|---|---|---|---|---|---|
| | Dakota | | Durango | | Dakota | | Durango | |
| | Claims | Rate (%) | Claims | Rate (%) | Claims | Rate (%) | Claims | Rate (%) |
| 1997 | 1,703 | *2.1%* | -- | -- | 1,182 | *2.5%* | -- | -- |
| 1998 | 1,982 | *1.8%* | -- | -- | 1,115 | *2.7%* | 2,727 | *2.2%* |
| 1999 | 2,979 | *3.6%* | 1,476 | *3.2%* | 2,707 | *5.2%* | 5,396 | *3.4%* |
| 2000 | 3,017 | *2.6%* | 1,513 | *2.8%* | 2,822 | *3.9%* | 4,413 | *3.1%* |
| 2001[26] | 3,410 | *3.9%* | 1,408 | *3.7%* | 2,486 | *3.5%* | 1,975 | *2.0%* |
| 2002[27] | 3,127 | *4.0%* | 1,040 | *2.9%* | 1,938 | *2.9%* | 1,423 | *1.9%* |
| 2003[27] | 343 | *1.1%* | 274 | *1.7%* | 263 | *0.9%* | 229 | *0.7%* |

Table 11. Warranty claim summary.

[25] MY 2003 data is for full model year and includes vehicles with upper ball joints using one-piece bearing.
[26] Almost half of the population is still within the warranty age period in February 2004.
[27] All of the population is still within the warranty age period in February 2004.

| MY | Two-Wheel Drive | | | | | Four-Wheel Drive | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicles | OEM upper ball joints | | Average end-play (in.) | | Vehicles | OEM upper ball joints | | Average end-play (in.) | |
| | | | Avg | | | | | Avg | | |
| 1997 | | | | | | | | | | |
| 1998 | | | | | | | | | | |
| 1999 | | | | | | | | | | |
| 2000 | | | | | | | | | | |
| 2001 | | | | | | | | | | |
| 2002 | | | | | | | | | | |
| 2003 | | | | | | | | | | |
| **Total** | | | | | | | | | | |

| MY | Two-Wheel Drive | | | | | Four-Wheel Drive | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicles | OEM upper ball joints | | Average end-play (in.) | | Vehicles | OEM upper ball joints | | Average end-play (in.) | |
| | | No. | Avg mileage | Upper | Lower | | No. | Avg mileage | Upper | Lower |
| 1997 | | | | | | | | | | |
| 1998 | | | | | | | | | | |
| 1999 | | | | | | | | | | |
| 2000 | | | | | | | | | | |
| 2001 | | | | | | | | | | |
| 2002 | | | | | | | | | | |
| 2003 | | | | | | | | | | |
| **Total** | | | | | | | | | | |

Table 13. DCC survey summary, subject vehicles with greater than 50,000 miles.

| MY | Two-Wheel Drive | | | | | Four-Wheel Drive | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicles | OEM upper ball joints | | Average end-play (in.) | | Vehicles | OEM upper ball joints | | Average end-play (in.) | |
| | | No. | Avg mileage | Upper | Lower | | No. | Avg mileage | Upper | Lower |
| 1997 | | | | | | | | | | |
| 1998 | | | | | | | | | | |
| 1999 | | | | | | | | | | |
| 2000 | | | | | | | | | | |
| 2001 | | | | | | | | | | |
| 2002 | | | | | | | | | | |
| 2003 | | | | | | | | | | |
| **Total** | | | | | | | | | | |

Table 14. DCC survey summary, subject vehicles with less than 50,000 miles.

| MY | Two-Wheel Drive | | | | | Four-Wheel Drive | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicles | Maximum UBJ end-play > 0.060” | | | | Vehicles | Maximum UBJ end-play > 0.060” | | | |
| | | No. OOS | % of vehicles | Audible noise | % with noise | | No. OOS | % of vehicles | Audible noise | % with noise |
| 1997 | | | | | | | | | | |
| 1998 | | | | | | | | | | |
| 1999 | | | | | | | | | | |
| 2000 | | | | | | | | | | |
| 2001 | | | | | | | | | | |
| 2002 | | | | | | | | | | |
| 2003 | | | | | | | | | | |
| **Total** | | | | | | | | | | |

Table 15. DCC survey summary, subject vehicles with out-of-specification upper ball joints.

| MY | Two-Wheel Drive | | | | | Four-Wheel Drive | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicles | Maximum UBJ end-play > 0.060” | | | | Vehicles | Maximum UBJ end-play > 0.060” | | | |
| | | No. OOS | % of vehicles | Audible noise | % with noise | | No. OOS | % of vehicles | Audible noise | % with noise |
| 1997 | | | | | | | | | | |
| 1998 | | | | | | | | | | |
| 1999 | | | | | | | | | | |
| 2000 | | | | | | | | | | |
| 2001 | | | | | | | | | | |
| 2002 | | | | | | | | | | |
| 2003 | | | | | | | | | | |
| **Total** | | | | | | | | | | |

Table 16. DCC survey summary, vehicles with out-of-specification upper ball joints (> 50,000 miles).

| MY | Two-Wheel Drive | | | | | Four-Wheel Drive | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicles | Maximum UBJ end-play > 0.060” | | | | Vehicles | Maximum UBJ end-play > 0.060” | | | |
| | | No. OOS | % of vehicles | Audible noise | % with noise | | No. OOS | % of vehicles | Audible noise | % with noise |
| 1997 | | | | | | | | | | |
| 1998 | | | | | | | | | | |
| 1999 | | | | | | | | | | |
| 2000 | | | | | | | | | | |
| 2001 | | | | | | | | | | |
| 2002 | | | | | | | | | | |
| 2003 | | | | | | | | | | |
| **Total** | | | | | | | | | | |

Table 17. DCC survey summary, vehicles with out-of-specification upper ball joints (< 50,000 miles).

## List of Figures

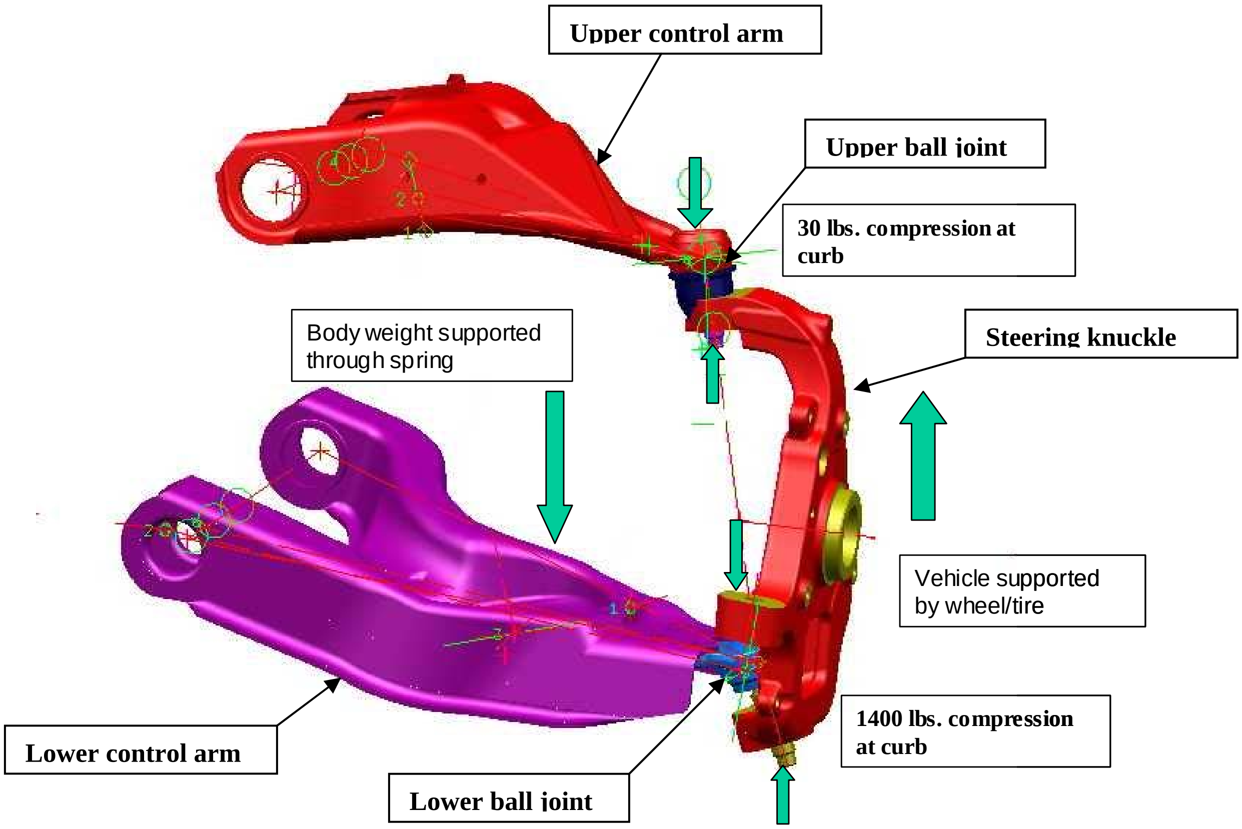


Figure 15. Durango Front Suspension at Curb.

Figure 16a. Dakota 4x2 right front upper ball joint vertical load cross plot, DCC public road course.[28]

Figure 16b. Durango 4x4 right front upper ball joint vertical load cross plot, DCC public road course.[28]

[28] DCC's instrumentations of the right-front upper ball joints resulted in opposite polarities for the data collected from the 4x2 and 4x4 vehicles. Also, note that the scale for the 4x4 vehicle is significantly larger than for the 4x2, the 4x2 data ranges from about [redacted] lbs compression to [redacted] lbs tension and the 4x4 data ranges from about [redacted] lbs compression to about [redacted] lbs tension.

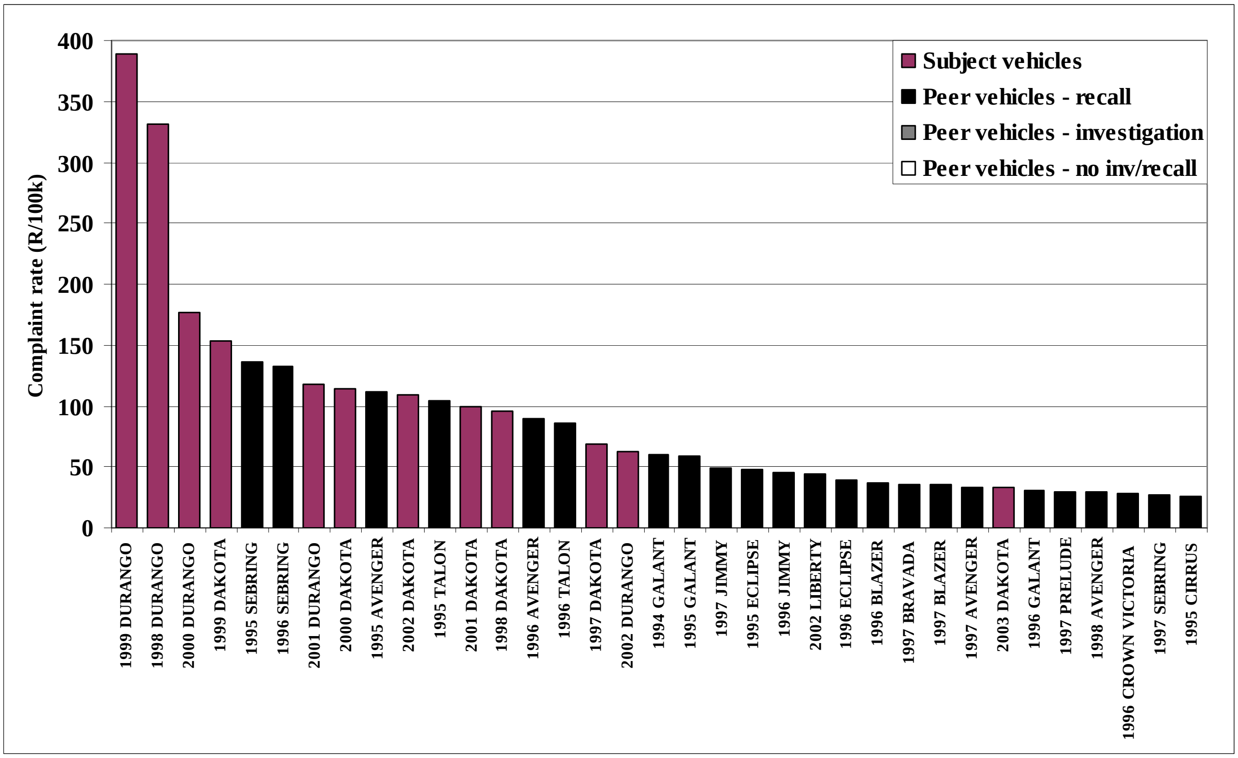


Figure 17. ODI complaint rate comparison – front suspension ball joints over last 10 years.[29]

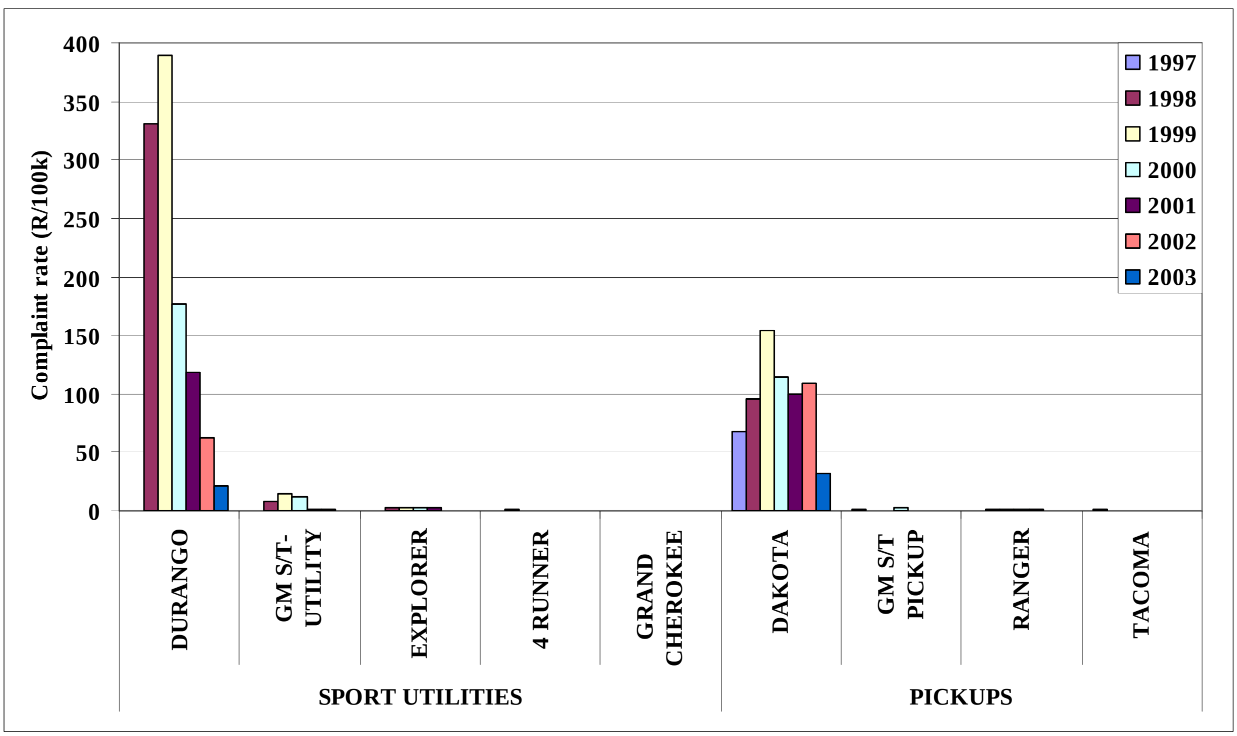


Figure 18. Subject vehicles compared with peers (MY 1997-2003 pickup trucks
MY 1998-2003 sport utilities), ODI front suspension ball joint complaint rate.

[29] The peer vehicles with recall include all peer MY/Model combinations where some portion of the population was recalled for a front suspension ball joint separation condition.


Figure 19.  Sectioned upper ball joint – MY 2002 Dakota 4x4 – 44,000 miles – 0.263 inches end-play:
(a) sectioned part – ball wear = 1.1 mm, throat wear = 1.4 mm; and (b) bearing wear, inboard view.

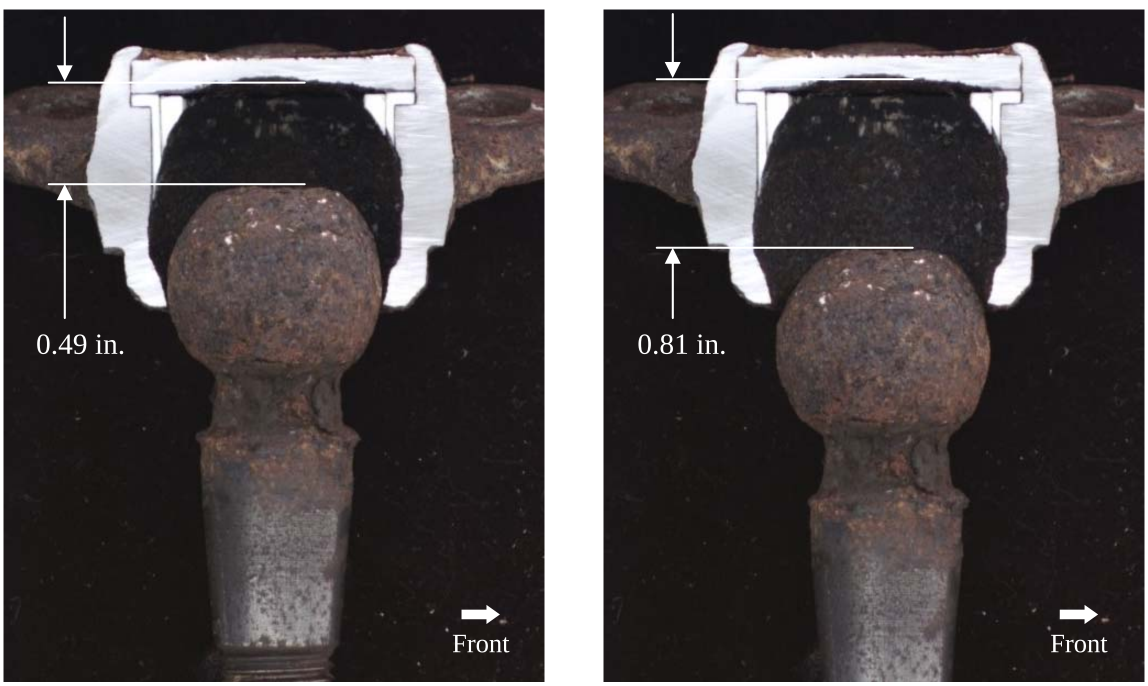


Figure 20.  Sectioned right-front upper ball joint from separation incident;
MY 2001 Dakota 4x4 – 27,900 miles – 55 mph – wheel separation;
DCC count = NO (“Insufficient information available”).

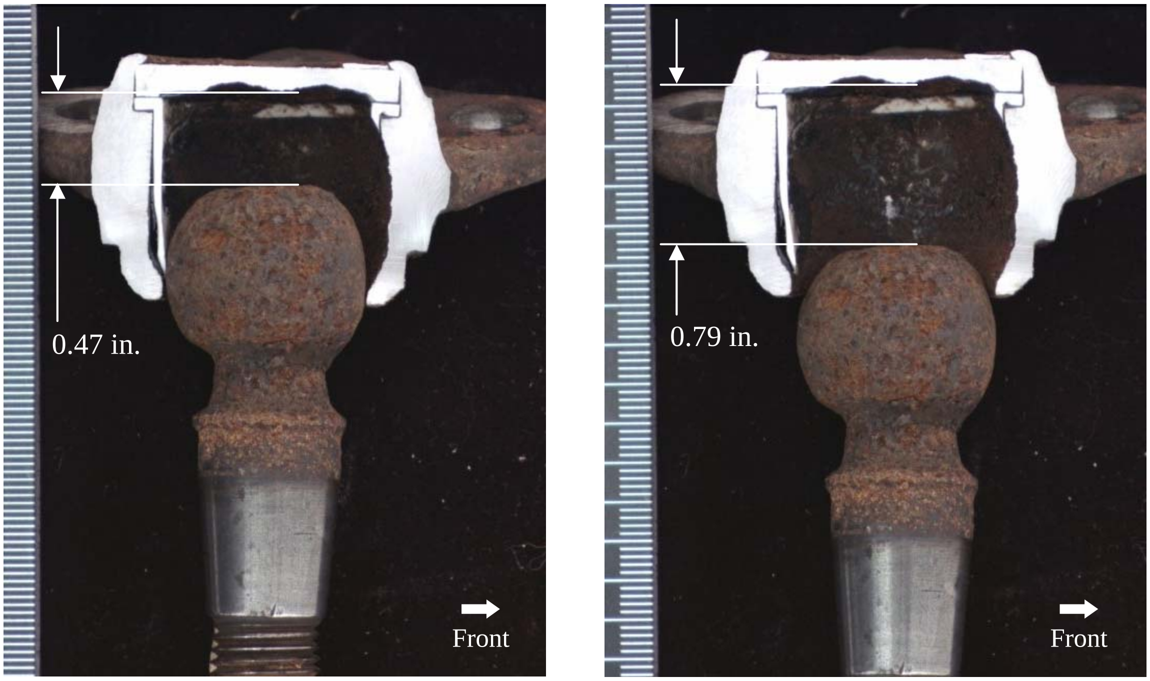


Figure 21. Sectioned right-front upper ball joint from separation incident;
MY 2000 Durango 4x4 – 60,000 miles – 45 mph – wheel separation = yes;
DCC count = YES.

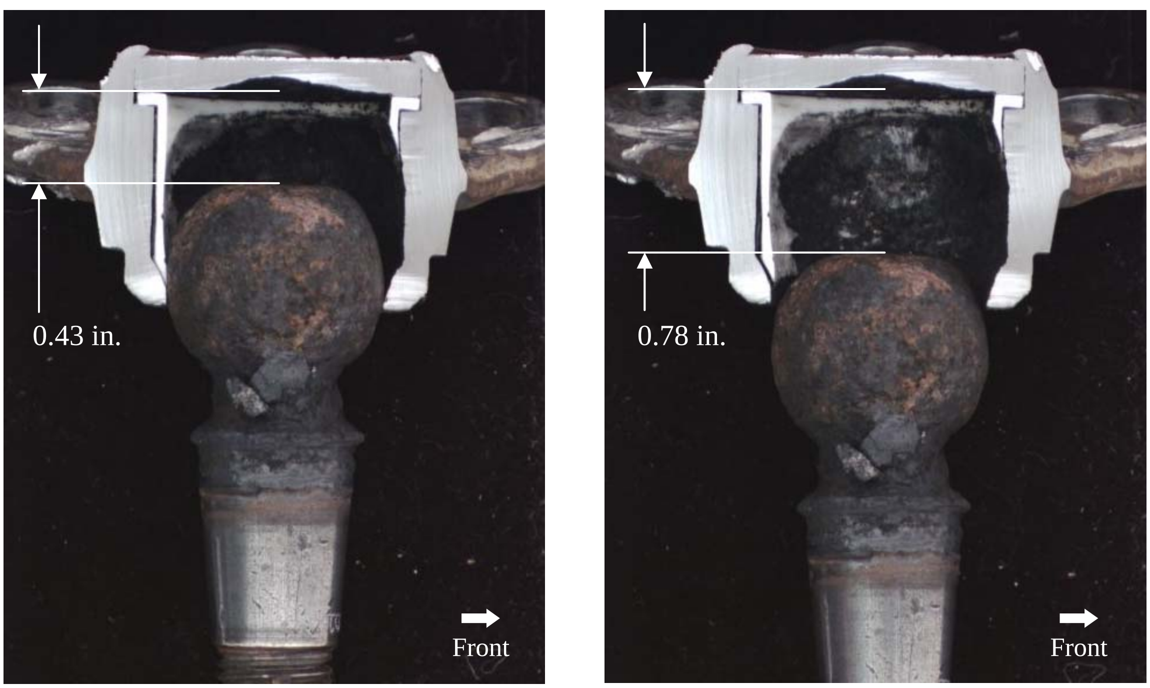


Figure 22. Sectioned right-front upper ball joint from separation incident;
MY 2001 Dakota 4x4 – 58,000 miles – 5 mph – suspension collapse;
DCC count = NO ("Alleged wheel separation – not confirmed").

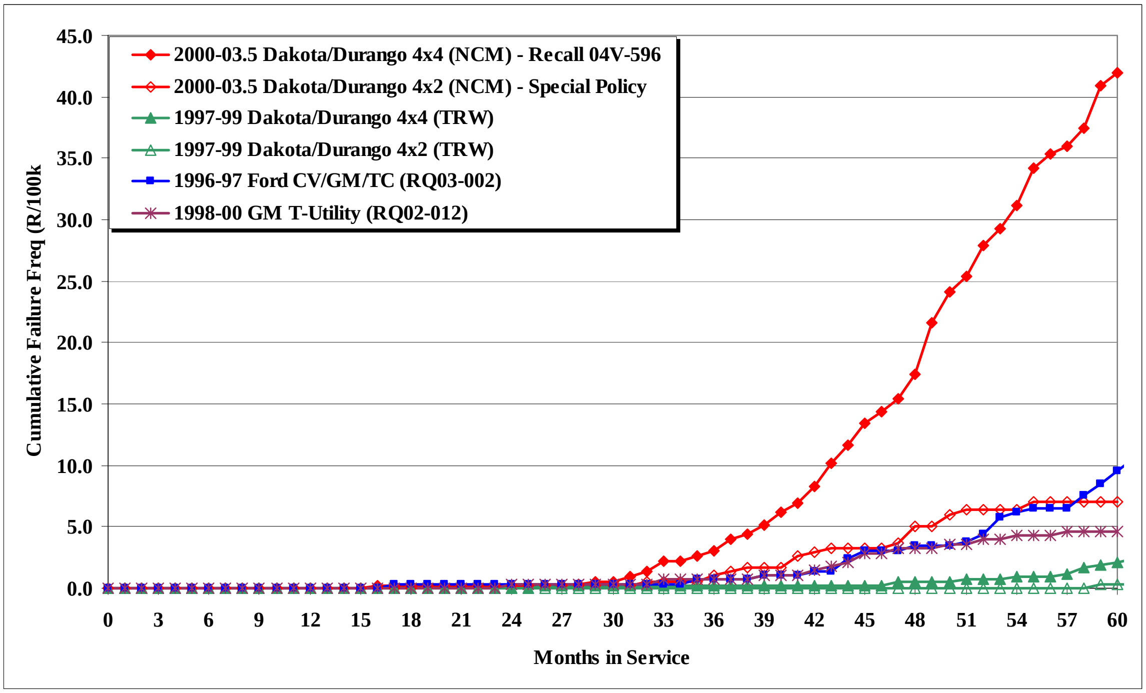


Figure 23. Cumulative failure frequency, subject vehicles using ODI complaints and peer investigations (RQ02-012 and RQ03-002).

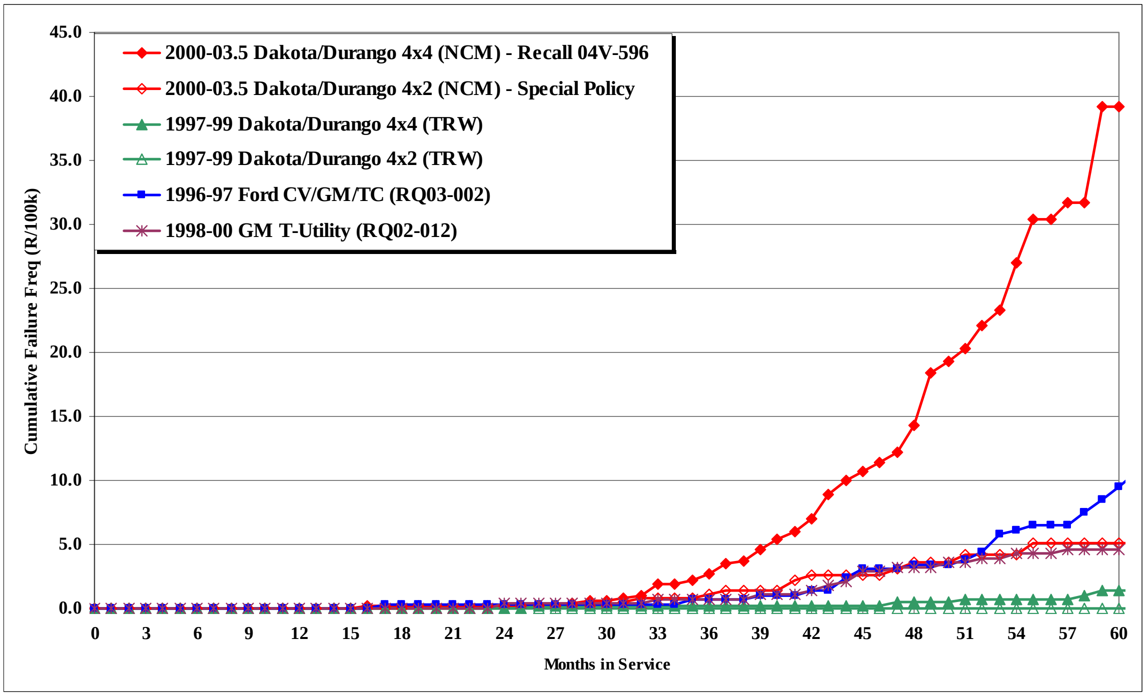


Figure 24. Cumulative failure frequency, subject vehicles ***using DCC complaints*** and peer investigations (RQ02-012 and RQ03-002).

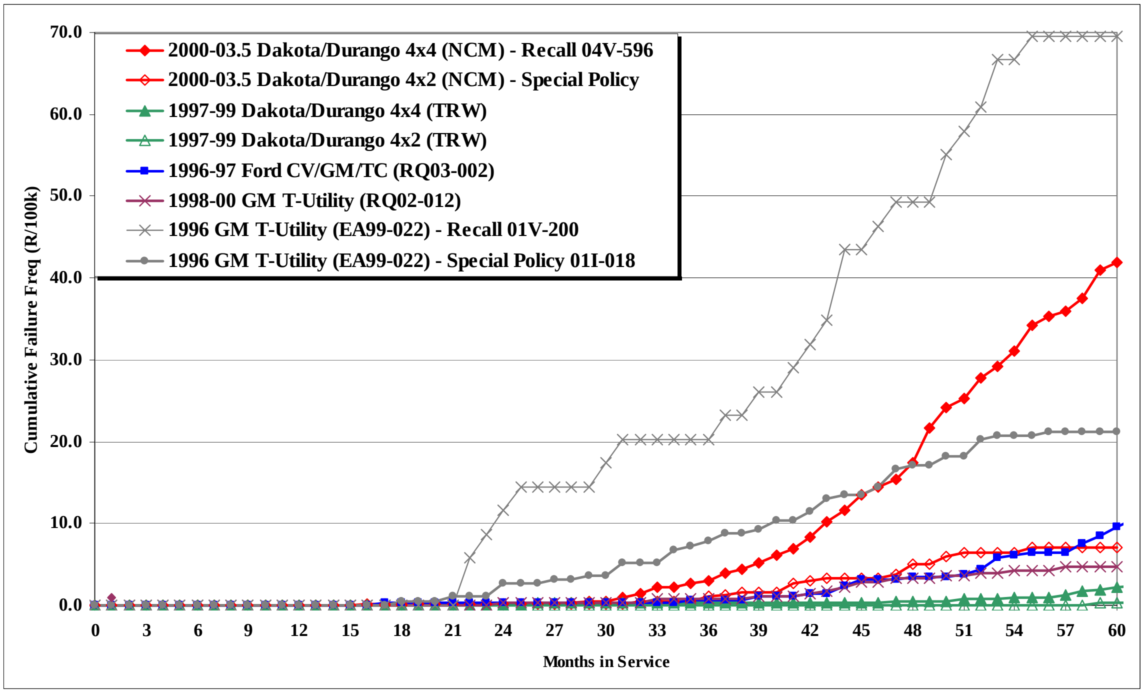


Figure 25. Cumulative failure frequency, subject vehicles using ODI complaints and peer investigations (RQ02-012, RQ03-002, and EA99-022).

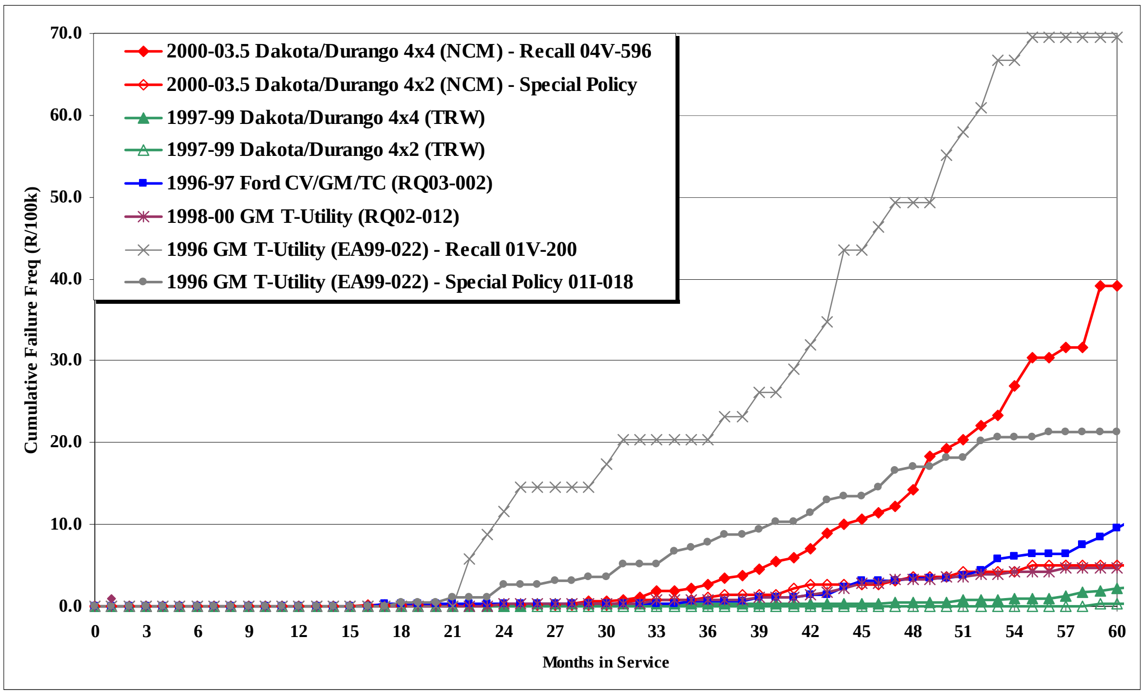


Figure 26. Cumulative failure frequency, subject vehicles ***using DCC complaints*** and peer investigations (RQ02-012, RQ03-002, and EA99-022).

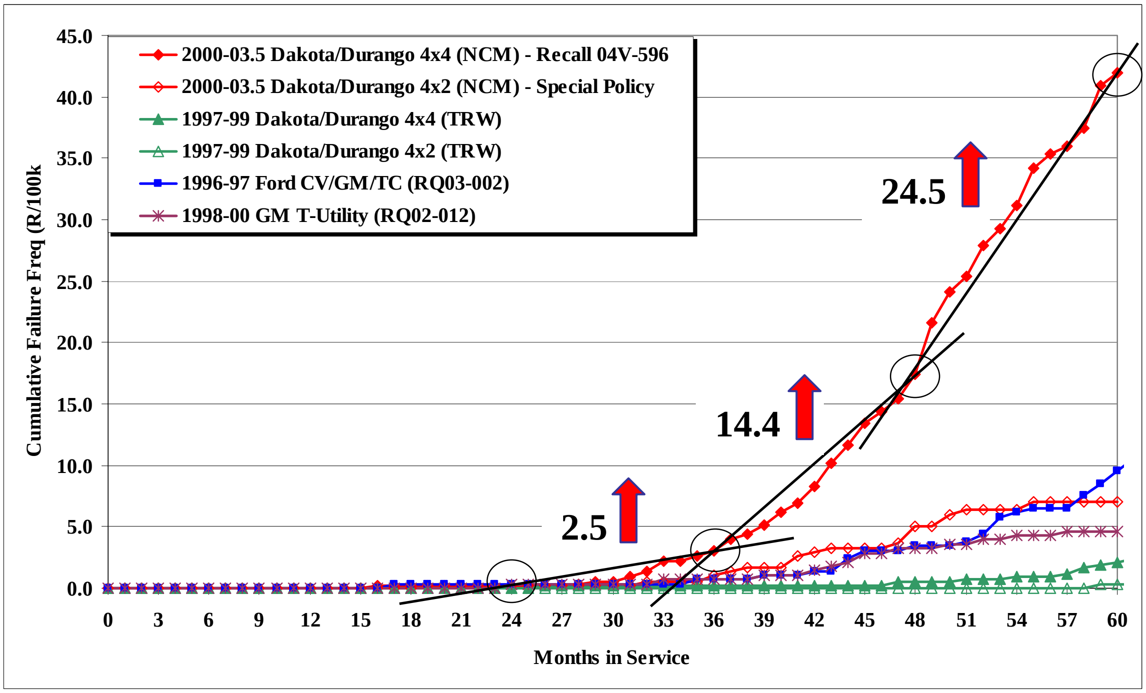


Figure 27. Failure trend analysis, using ODI complaints.

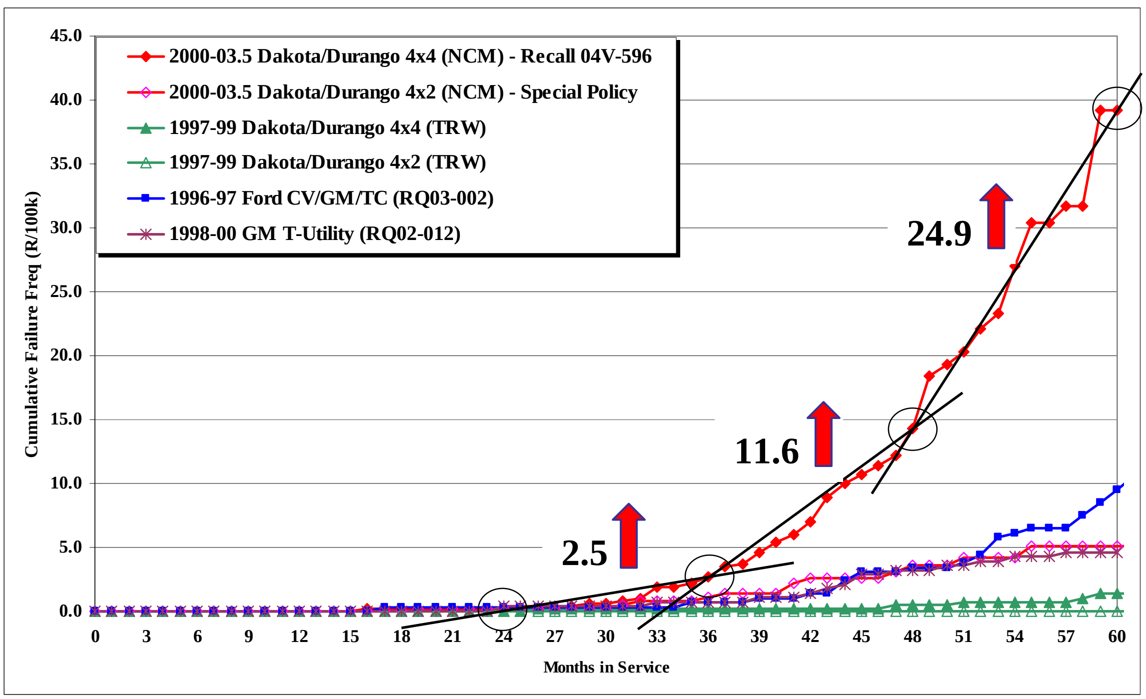


Figure 28. Failure trend analysis, using ***<u>DCC complaints</u>***.

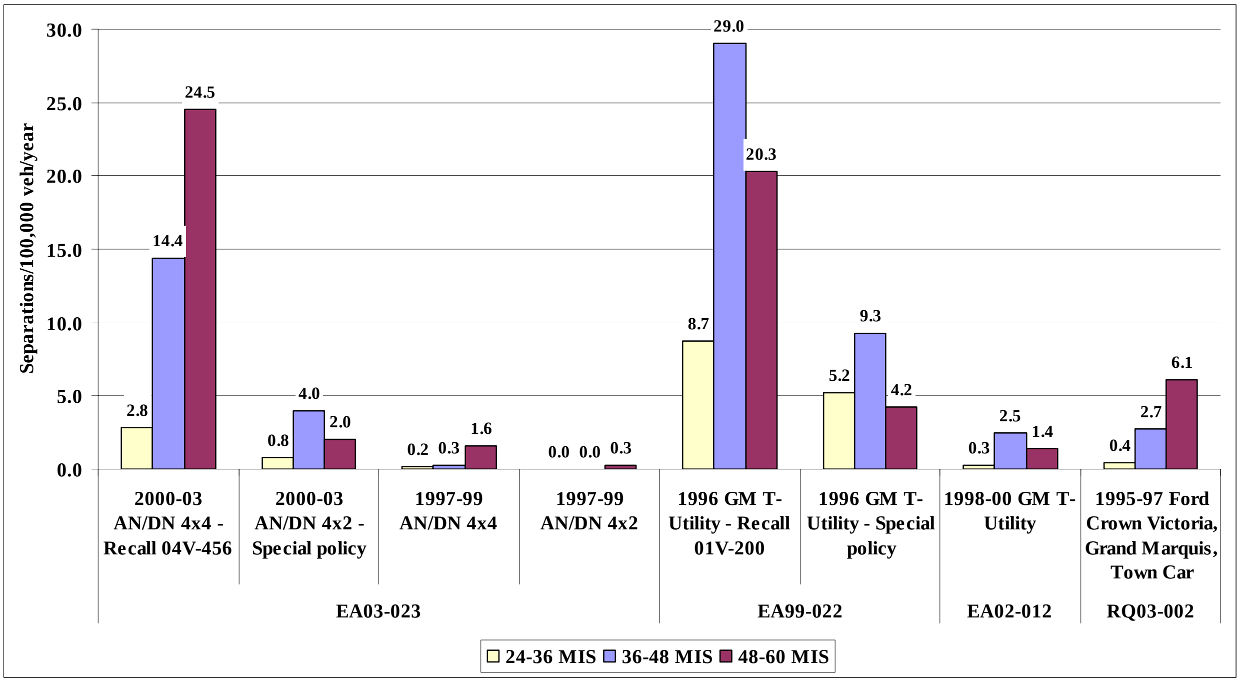


Figure 29. Separation rate trends from: (1) 24-36 months in service; (2) 36-48 months in service; and (3) 48-60 months in service, for subject vehicles using ODI counts and peer investigations.

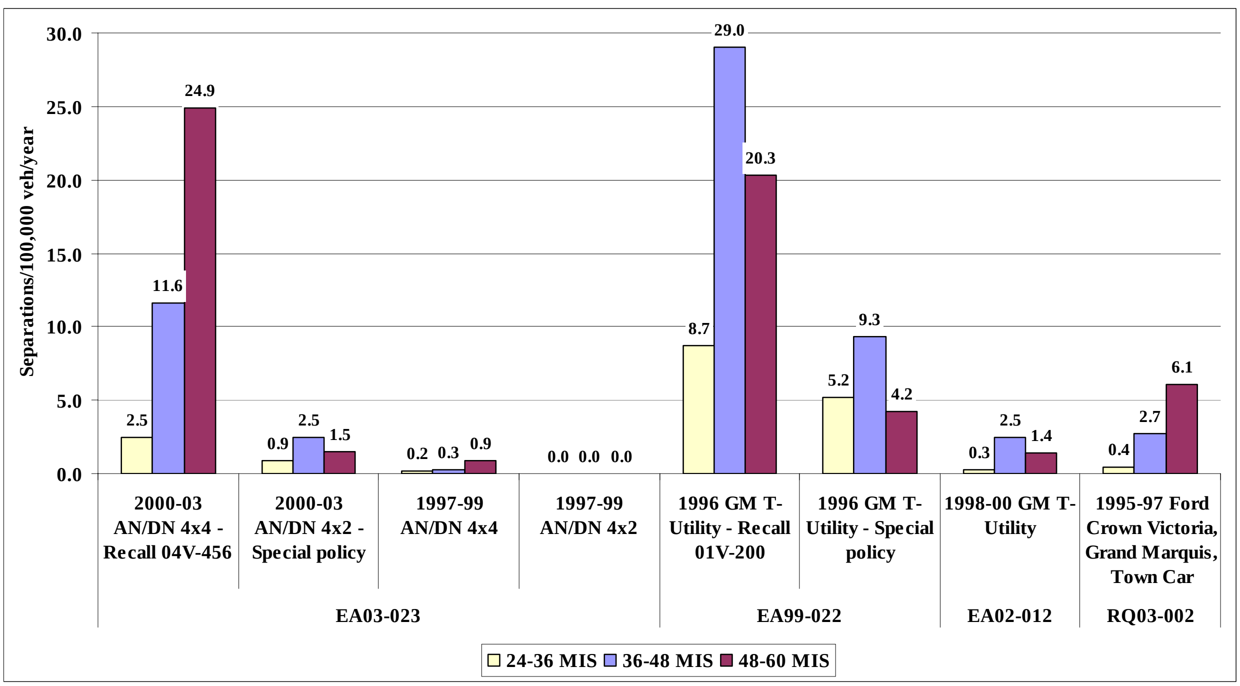


Figure 30. Separation rate trends from: (1) 24-36 months in service; (2) 36-48 months in service; and (3) 48-60 months in service, for subject vehicles ***using DCC counts*** and peer investigations.

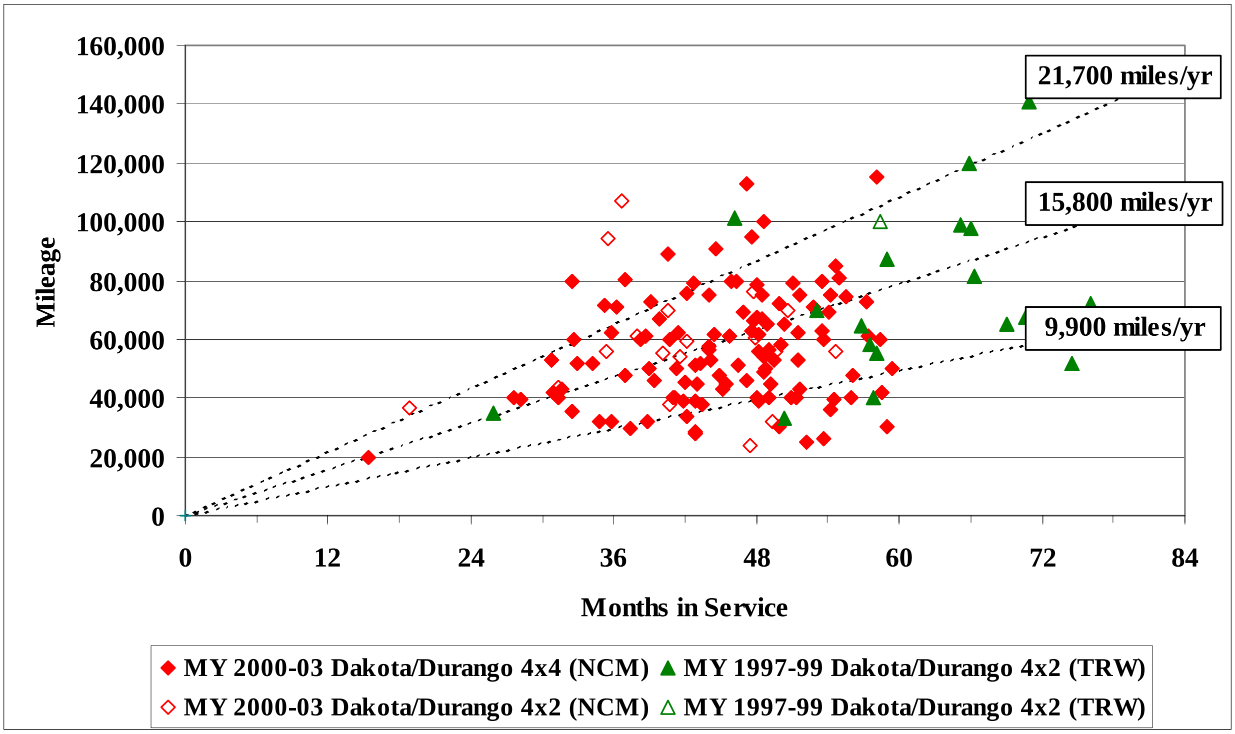


Figure 31. Separation incidents plotted by months-in-service and mileage (using ODI counts), with mean and +/- standard deviation trend lines for total fleet mileage accumulation.[30]

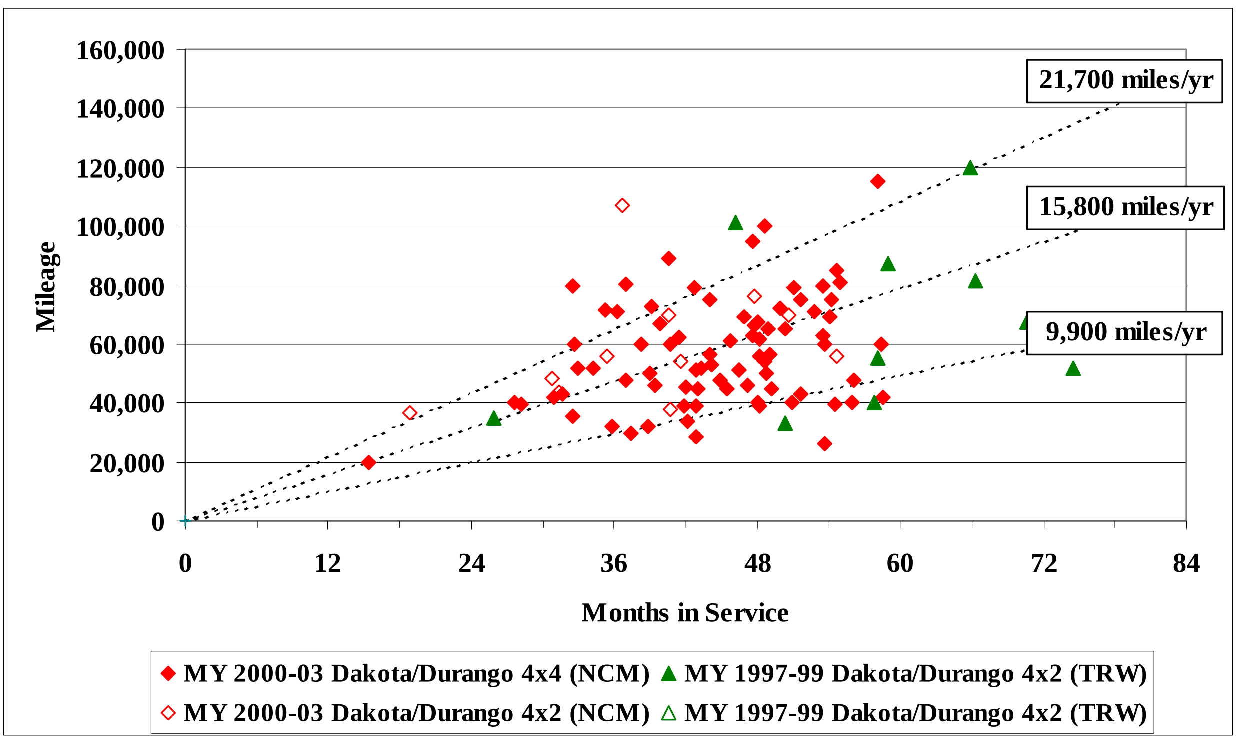


Figure 32. Separation incidents plotted by months-in-service and mileage (***using DCC counts***), with mean and +/- standard deviation trend lines for total fleet mileage accumulation.[30]

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[30] Trend lines are for average target vehicle fleet mileage accumulation and +/- standard deviation (5,900 miles). These lines are approximations - actual mileage accumulation declines with vehicle age.