U.S. Department of Transportation

National Highway Traffic Safety Administration

ODI RESUME

OFFICE OF DEFECTS INVESTIGATION

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Investigation: EA 11-007
Prompted by: VOQ 10357608 & 10357609
Date Opened: 05/27/2011 **Date Closed:** 07/16/2012
Investigator: Tom Bowman **Reviewer:** Bruce York-B
Approver: Frank Borris
Subject: Wheel Separations (Broken Studs)

MANUFACTURER & PRODUCT INFORMATION

Manufacturer: DOUBLETREE RV, DRV SUITES
Products: MY 2008, 2009, 2010 DoubleTree (DRV) Recreational Vehicles
Population: 1,701

Problem Description: Loss of wheel clamp may cause broken wheel mounting studs which can possibly result in a wheel separation.

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	2	15	15**
Crashes/Fires:	0	0	0
Injury Incidents:	0	0	0
Fatality Incidents:	0	0	0

** Total eliminates duplicates received by ODI and manufacturer.

ACTION / SUMMARY INFORMATION

Action: Close this investigation.

Summary:

EA11-007 is closed with the submission of recall campaign 12V-028 submitted by DRV. The population included in the campaign action includes 1,701 model year 2008, 2010, and early-2011 DRV models Select, Mobile, and Elite Suite DRV motor homes equipped with disc brakes.

The absence of wheel end loosening and/or separation reports related to DRV vehicles produced after January 2011 indicates that changes in manufacturing practices that DRV adopted have improved the integrity of the wheel end system in these vehicles.

Further details of this investigation are summarized in the attached closing report.

The ODI reports cited above can be reviewed at www-odi.nhtsa.dot.gov/complaints under the following identification (ODI) numbers: 10357608, 10357609

Closing Report – EA11-007
(Formerly PE10-040)

Risk of Wheel Separation Due to Wheel Mounting Stud Fractures Caused by Diminished Clamp in Model Year 2009, 2010, and 2011 DRV (formerly DoubleTree RV) Recreational Vehicles

CONTENTS

(1) Subject Components -

This report summarizes the Office of Defects Investigation's (ODI's) investigation of wheel separations that have occurred in model year 2009, 2010, and 2011 DRV (formerly DoubleTree RV) "towable" recreational vehicles. These wheel separations are preceded by, and the result of, the complete fracture of all eight of the wheel mounting studs on the affected wheel.

The affected DRV vehicles were equipped with one of two types of wheel retention systems as summarized in Table 1 below. Both wheel retention systems were addressed by EA11-007 investigation activity and subsequent campaign action 12V-028.

Table 1- DRV Wheel Mounting System Configurations

Wheel Retention System Type	Nominal Wheel Diameter	Number of Mounting Studs	Nominal Stud Diameter	Nominal Installation and Maintenance Wheel Mounting Nut Torque Specification
A	16" Aluminum, stud piloted	8 on 6-1/2" circle	9/16"	125 lb-ft
B	17-1/2" Aluminum, hub piloted	8 on 6-1/2" circle	3/4"	150 lb-ft

(2) Background-

ODI first learned of two reported complete or partial [(1)] wheel separation incidents, summarized in VOQ 10357608 and VOQ 10357609, in June 2010.

[(1)] For purposes of this report, ODI has used the term "partial separation" to indicate those incidents in which one or more wheel mounting studs had fractured but the remaining, un-fractured stud(s) had prevented the wheel from separating completely from the vehicle. Unless the loosened condition of a "partial wheel separation" is detected and corrected, complete separation of the wheel is imminent. Investigation of partial separations can provide useful insights regarding the factors contributing to complete separations. For these reasons, the circumstances pertaining to partial separations are investigated and partial separations are counted in the incident summaries which are provided in Appendices A-C of this report.

Following receipt of the initial VOQ complaints, ODI requested DRV to review their complaint records and identify all reported incidents of a similar nature. On September 30, 2010, in response to this request, DRV provided a short summary of three previous incidents of partial or complete wheel separations.

These five known partial or complete wheel separation incidents (Incidents 1 -5) are summarized in Appendix A and the constituted the basis for ODI's investigation PE10-040 which was initiated in October 14, 2010.

Appendices B and C summarize the incident information regarding incidents that occurred during the course of active investigation PE10-014 and successor investigation EA11- 007.

(3) Chronology -

Appendix D lists the principle pertinent investigatory activities and milestones to date.

(4) Production Volumes -

DRV provided the pertinent production volumes (summarized in Table 2 below) in response to an ODI request. This summary includes only vehicles equipped with disc brakes; there have been no reported incidents pertaining to vehicles equipped with drum brakes.

Table 2 – DRV Production Volumes – Disc Brake Equipped

Model	2009 MY	2010 MY	2011 MY	Total
Elite Suite	33	30	14	77
Mobile Suites	254	269	159	682
Select Suites	7	14	2	23
Total	294	313	175	782

The above table identifies the scope of vehicles that have been under consideration in investigation EA11-007. DRV Campaign 12V-028 addresses MY 2008, 2010, and (partial year) 2011 vehicles which consists of 1,701 vehicles.

(5) Failure Mode -

Wheel separations that are associated with a reduction or loss of wheel-to-hub clamp typically begin with a preliminary loosening of the clamp of one or more wheel mounting studs which induces unintended bending forces on the studs and allows unintended fretting, "working," wearing, and/or abrasion of the wheel-to-hub mating surfaces which further diminishes the clamp integrity. The cumulative effect of the hub-to-wheel interface fretting and stud bending forces continues to degrade the integrity of the clamp and eventually, with continued use, fatigue cracks initiate in the mounting studs. When the wheel mounting studs are further subjected to repeated tensile and bending forces induced through normal vehicle operation, these fatigue cracks enlarge and propagate through the cross section of the stud until one or more of the studs cannot withstand further imposed forces, and fractures.

In 2004 ODI investigated similar wheel separations methods in towable recreational vehicles, including their associated wheel retention systems and

installation and maintenance practices. These findings are summarized in reports EA04-009 (Fleetwood); EA04-016 (Jayco); and EA04-032 (Keystone).

(6) Characteristics and Issues –

Many factors --- acting either alone or in combination --- contribute to variability in the joint integrity and may cause or contribute to compromised wheel end clamp. Based on prior investigative experience, one likely significant contributor is the presence of excess paint or other contaminants on the hub-to-wheel interface that can be reasonably linked to degradation of wheel end clamp integrity.

Inconsistent and/or inadequate assembly torque could also be considered as a possible contributing factor. In the course of this investigation, attempts were made to measure the wheel-mounting nut torque in in-service vehicles (summarized in Appendix E.) Measuring the wheel-mounting nut torque in in-service vehicles cannot indicate the integrity of the original assembly clamp but provides some value in assessing the adequacy and/or consistency of the wheel clamp integrity after some time-in-service exposure, including the effect of variations in maintenance regimens.

(7) Product Changes -

On November 30, 2010, in response to ODI's inquiry, DRV provided a summary of identified product changes. This summary indicates that DRV was not aware of any significant product or process changes, including variations in hub or wheel coatings, that may have affected clamp integrity during the model year 2009-2011 suspect production period. Nonetheless, this investigation determined that variations in hub paint processes --- previously unknown to DRV--- had occurred.

(8) ODI Investigation Activity –

In order to inspect the vehicle and wheel end conditions as soon as possible after the separation event (before the post-incident wheel end components were altered by repairs), ODI / VRTC conducted field inspection visits to Memphis, TN (Incident # 6, Appendix B) and Hutto, TX (Incident # 7, Appendix C). These field inspections were conducted in conjunction with DRV and their axle and/or hub suppliers. In most cases, parts were subsequently removed and returned to DRV for further examination.

ODI / VRTC conducted approximately 14 phone conferences (bi-weekly) with DRV to review progress on newly-reported incidents, audits of in-service vehicles, status of returned parts inspections, and related investigation activities.

ODI researched past investigation, recall history and related technical resources and provided that information to DRV (Appendix F).

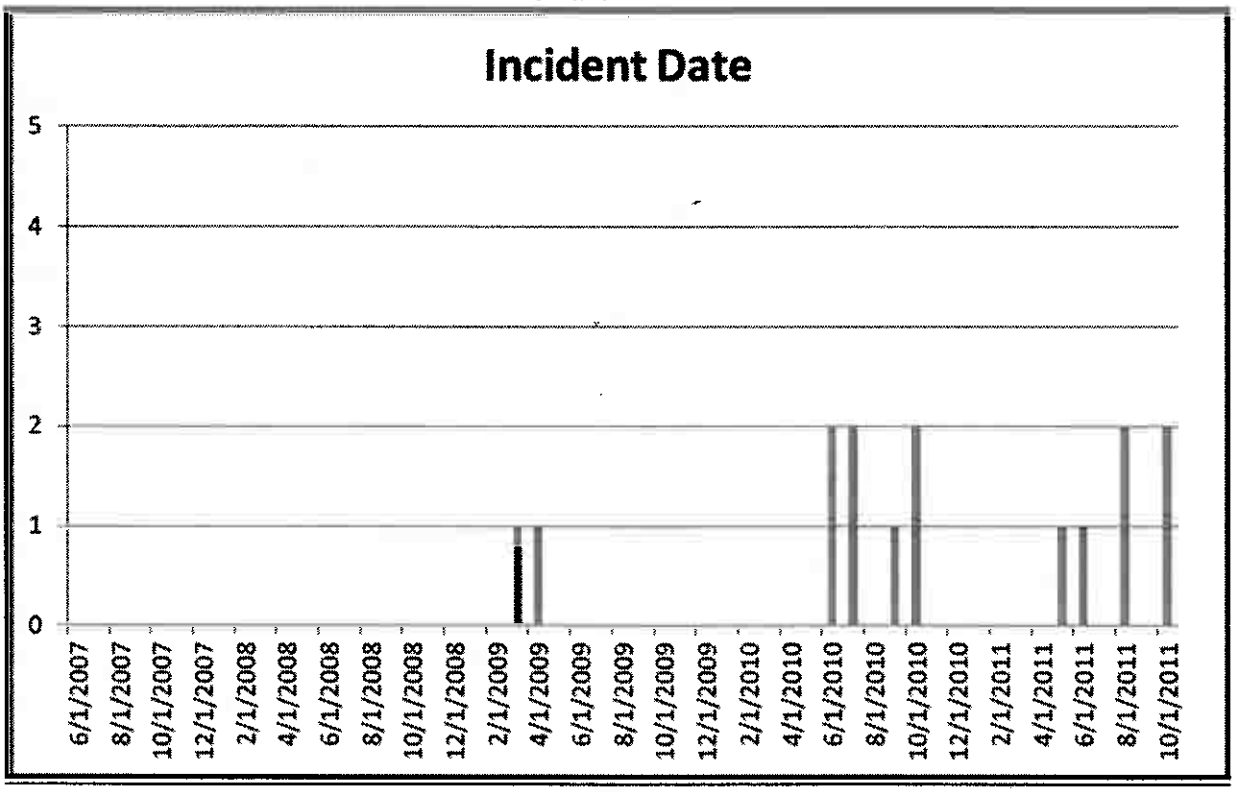
ODI periodically conducted informal phone inquiries at peer manufacturers and suppliers (primarily those who were the subject of the ODI investigations conducted in 2004) to determine whether these companies were aware of similar current wheel integrity issues affecting their products. These manufacturers reported that current problems / issues associated with wheel retention in newly manufactured vehicles are virtually non-existent.

(9) ODI Findings -

As summarized in Section (6) "Characteristics and Issues" above, ODI recognizes that many factors may contribute to wheel mounting nut loosening and subsequent loss of wheel clamp, stud breakage, etal.

Chart 1 (below) depicts the known partial or complete separation by incident date.

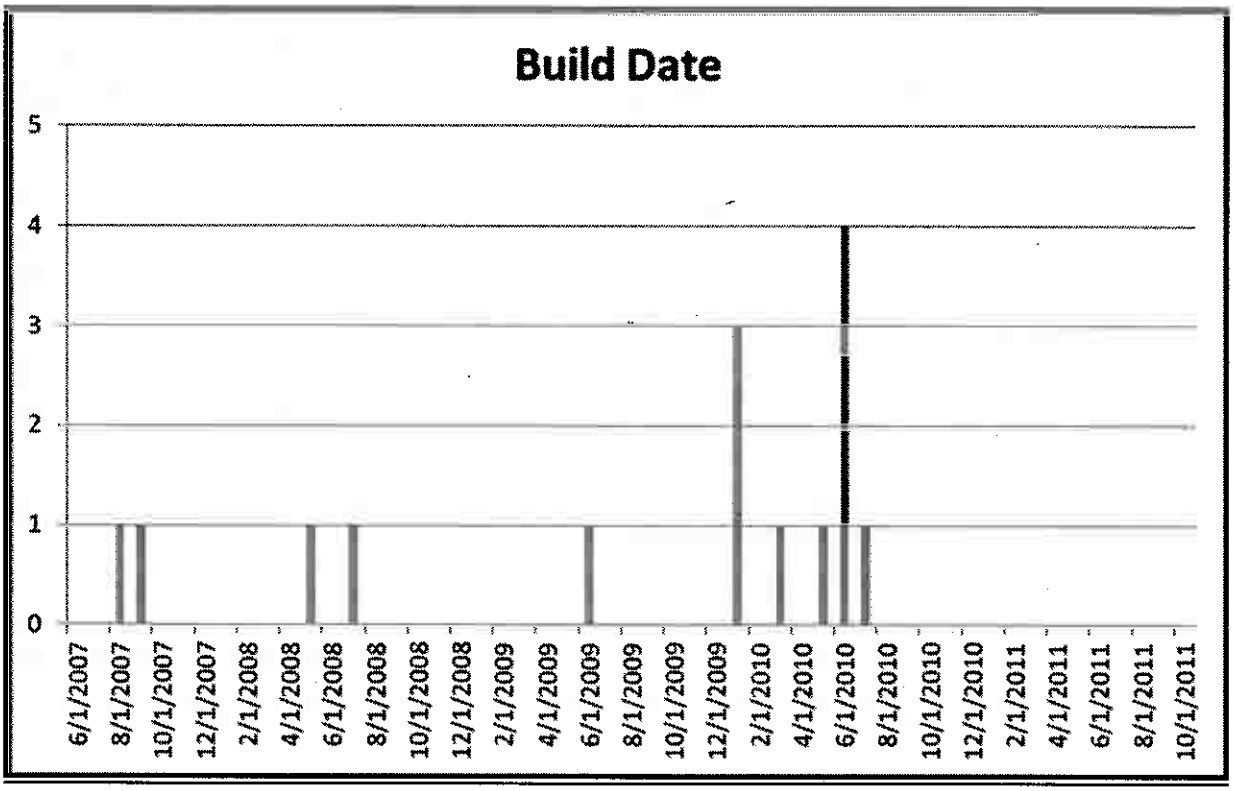
Chart 1



The incident data depicted consists of (a) the five incidents identified at the initiation of PE10-040 in October 2010; (b) incidents numbered 11 and 13 which had occurred prior to October, 2010, but had not been reported to DRV / ODI until after these owners became aware of DRV's investigation activity through the DRV advisory letters prompting the affected owners to report their earlier-occurring incidents; and (c) incidents that occurred during the investigation.

Chart 2 (below) depicts the known partial or complete wheel separations by vehicle build date.

Chart 2



As can be seen in Chart 2 above, there have been no reported complaints pertaining to vehicles manufactured after October, 2010, the general time period that corresponds to the initiation of PE10-040 and in the approximate time period of the paint removal procedure (January 2011) summarized in Section 7, "Product Changes" above.

The absence of post-October 2010 complaints supports the suspicion that excess paint in the hub and wheel clamp face has been a pertinent contributor to wheel clamp loss and subsequent wheel separation incidents.

The lack of reported incidents within the first year after production (i.e. since October 2011 when DRV removed the excess paint from wheel hub components) compares favorably to the prior production periods (of no-paint removal) in which nine of the reported incidents had occurred within the first twelve months of service.

It should be noted that DRV elected to campaign (12V-028) model year 2008, 2010, and 2011 vehicles which are the principle production periods that have contributed to wheel separation incidents. ODI and DRV will continue to monitor the ongoing situation, including the unaddressed MY 2009 vehicles, to determine whether the initial campaign scoping is appropriate.

(10) Manufacturer's Investigation Activity –

DRV participated and conducted several field inspections of vehicles that had experienced wheel separations. As a general policy, following each incident reported during the investigation period, DRV had the wheel end components removed, returned and inspected for such issues as fracture mechanism, confirmation of metallurgical properties (studs), and the thickness of the applied paint coatings. Reports summarizing these inspections are summarized below in Table 3. Copies of the complete reports are available in the public file for this investigation.

Table 3 – Laboratory Reports

Report Number	Date	Description
4398	June 15, 2011	Paint Thickness Measurement
2011-0932	June, 2011	Calgary Inspection Report
4446-1	Sept 5, 2011	Paint thickness Measurement
4446-2	Sept 7, 2011	Study cause of Stud Breakage
4478-1	Oct 12, 2011	Paint Thickness – Colorado vehicle
4446-3	Oct 24, 2011	Examine Bolt Hole Surfaces - Calgary vehicle
4446-4	Oct 26, 2011	Check for cracks in studs removed from Calgary vehicle

DRV implemented and managed a field audit (check of wheel mounting nut torques on vehicles available to them for other non-wheel service issues) of 24 vehicles with varying time-in-service exposure. Generally, this survey determined that owners frequently failed to "check" the torque of wheel nuts during the period of early "break-in" use. The survey also generally found that owners or subsequent service technicians applied excess torque (above specified range) ostensibly as an over-precaution against subsequent in-service wheel nut loosening. See Appendix E.

DRV issued field notifications in December, 2010 and July, 2011 for the purpose of informing owners of the recommended torque procedure and to encourage owners who experienced difficulty in maintaining torque to contact DRV to assist in resolving the condition.

DRV has proposed conducting Campaign 12V-028 to further address the suspected issues.

(11) Investigation Findings –

Evidence indicating that excess paint in the clamp joint is a principle contributing issue contributing of joint loosening:

(1) DRV has installed hubs with paint free surfaces since January 2011. No separations or nut loosening are known to have occurred since this change was implemented. By comparison, nine wheel separations had occurred within an equivalent one-year time period in production that preceded this improvement.

(2) Excess paint (or equivalent coatings or contaminants) has been generally recognized (in published literature, etc.) as a prime suspect associated reduction in clamp integrity.

The DRV-retained laboratory metallurgist confirmed that excess paint can compromise joint integrity.

Prudent application of paint or other coatings provides a useful barrier against corrosion and improves the cosmetic appearance of vehicles. Though there may be industry debate over allowable paint films, the paint thickness measured on DRV returned material from wheel separation incidents have exceeded general industry guidelines for maximum allowable coating thicknesses.

(3) One DRV owner had experienced a partial wheel separation (incident # 10) and subsequently had experienced persistent wheel nut loosening. After the paint was removed from the hub-wheel interface, the nut torque stabilized at the applied torque without issue through a 1000 mile trip.

(4) Based on ODI's periodic inquiries at vehicle manufacturers associated with earlier (2004-2005) wheel separation investigations, paint removal and attention to assembly practices (torque control) appears to have effectively addressed wheel retention issues in the towable recreational RV populations that ODI had previously investigated.

(5) ODI notes the absence of reported incidents in DRV vehicles equipped with drum brakes. Since the wheel installation and nut-torquing procedures at DRV is unlikely to differ significantly between vehicles equipped drum and those equipped with disc brakes, the difference in performance data is highly indicative that the clamp loosening issues are related to differences between the components' attributes --- such as the differences in the above-referenced paint coatings.

(12) ODI Reasons for Closing -

Given the forgoing assessment, ODI believes that the DRV decision to remedy the designated vehicle population with the actions summarized in 12V-028 is an appropriate response to the issues identified and investigated in EA11-007.

ODI has also requested that DRV notify ODI of all newly-reported wheel separation incidents within 48 hours of notification for a one year period from the date of the campaign (i.e. until January, 2013).

(13) Concurrence -

Submitted by:

7/5/12

G T Bowman
ODI Investigator

Bruce York Chief
Medium and Heavy Vehicle, ODI

Frank Borris
ODI Office Director

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Appendix A

Incidents Reported Prior To October 2010 – Five Incidents

Incident Number	Incident Date	Vehicle Designation	Vehicle Build Date	Description	Estimated Mileage	Intervening Wheel End Servicing	Nominal Wheel Size
1 Las Vegas, NV	3/11/2009	36TKSB	8/18/2008	complete separation of "door side" wheel	Unknown	Unknown	16"
2 Littleton, CO	6/7/2010	36TK	7/16/2009	VOQ 10357609: partial separation of left rear wheel	Unknown	Unknown	16"
3 Limon, CO	6/22/1010	36TKSB	2/3/2010	VOQ 10357608: complete separation of "door side" wheel	Unknown	Unknown	16"
4 Lafayette, LA	7/22/2010	36TKSB	7/19/2010	complete wheel separation	Unknown	Unknown	16"
5 Ardmore, TX	9/23/2010	36TKSB	2/24/2010	complete separation of "door side" front wheel	Unknown	Unknown	16"

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Appendix B

Incidents Reported Between October 2010 and December 2011 Involving DRV Vehicles Equipped with 16" Wheels – Eight Incidents

As a part of this investigation, ODI had requested DRV to notify the Agency promptly of all newly-reported incidents of partial or complete wheel separations.

During this investigation / monitoring period, DRV reported ten additional incidents. Eight of the affected vehicles had been equipped with 16" diameter wheels are summarized below. Two of the affected vehicles had been equipped with 17-1/2" diameter wheels are summarized in Appendix C.

Incident Number	Incident Date	Vehicle Designation	Vehicle Build Date	Description	Estimated Mileage	Intervening Wheel End Servicing
6 Memphis, TN	10/27/2010	Mobile Suites (# 5480)	8/9/2010	Complete separation of driver side forward wheel	Unknown	None by Owner
8 Calgary (Inspected by Collision Analysis under contract to Transport Canada)	6/18/2011	36TKSB3 (Mobile Suites) (# 5458)	6/21/2010	Complete separation of off door side rear wheel	3000 - 4000	Checked nuts before trip in March (not using torque wrench)
9 Springdale, Ark	8/5/2011	32TK3 (Mobile Suites) (4094)	9/4/2007 Axles replaced in May 2010	Right rear wheel noted wobbling	Unknown	Owner does not re-torque wheel nuts

ODI and/or VRTC conducted a field inspection of the wheel ends associated with incident No. 6 (Memphis, TN). Transport Canada inspected the wheel ends associated with incident No 8.

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Appendix B (cont'd)

Incidents Reported Between October 2010 and December 2011 Involving DRV Vehicles Equipped with 16" Wheels – Eight Incidents

Incident Number	Incident Date	Vehicle Designation	Vehicle Build Date	Description	Estimated Mileage	Intervening Wheel End Servicing
10 Gunison, CO	8/15/11	(# 5349)	4/2010	Partial separation of passenger side wheel	Unknown	Observers reportedly noted flat tire -- actually wheel had loosened
11 Las Vegas, NV	7/31/10	36RSSB3 (# 5288)	2/15/2010	Complete separation of "off door rear wheel"	Unknown	Owner claims regular pre-trip torque check: last one was 220 miles prior to incident
13 Platte, NE	4/1/2009	36TK3	10/24/2007	Complete separation of door side rear wheel (pass side); never recovered	ODI inquiry: whose hub-brake?	Torqued to 110 lbs-ft rather than specified 125 lbs-ft.
14 Savannah, GA	10/5/2011	36RSSB3	6/13/2008	Complete separation of drivers side rear	Unknown	Owner states tightened with hand wrench 4 days prior to incident
15 Hart, MI	10/13/2011	36TKSB	7/15/2010	Complete separation of off door (driver's side)	Unknown	Unknown

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Appendix C (cont'd)

Incidents Reported Between October 2010 and December 2011 Involving DRV Vehicles Equipped with 17-1/2" Wheels – Two Incidents

Incident Number	Incident Date	Vehicle Designation	Vehicle Build Date	Description	Estimated Mileage	Intervening Wheel End Servicing
7 Hutto, TX	5/1/2011	36RSSB3 (Elite) (# 5496)	7/27/2010	Low speed complete separation of passenger side rear wheel	1,000 delivery miles & 1,000 in-use miles	None by owner
12 Little Rock, AR	10/30/10	38TKSB Mobile Suites	7/14/2010	Complete separation off door side (driver side) ; never recovered	First Trip	owner did not check torque

ODI and/or VRTC conducted a field inspection of the wheel ends associated with incident No. 7 (Hutto, TX).

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Since the initiation of this investigation, available wheel ends parts (wheels, studs, hub) removed from the affected wheel end, as well the wheel end equipment from the other "corners" of the vehicle, have been removed and returned to DRV for analysis. Refer to Table 3 in the body of this report for a listing of the pertinent inspection reports.

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Appendix D

Summary of Principle Investigation Activity Events

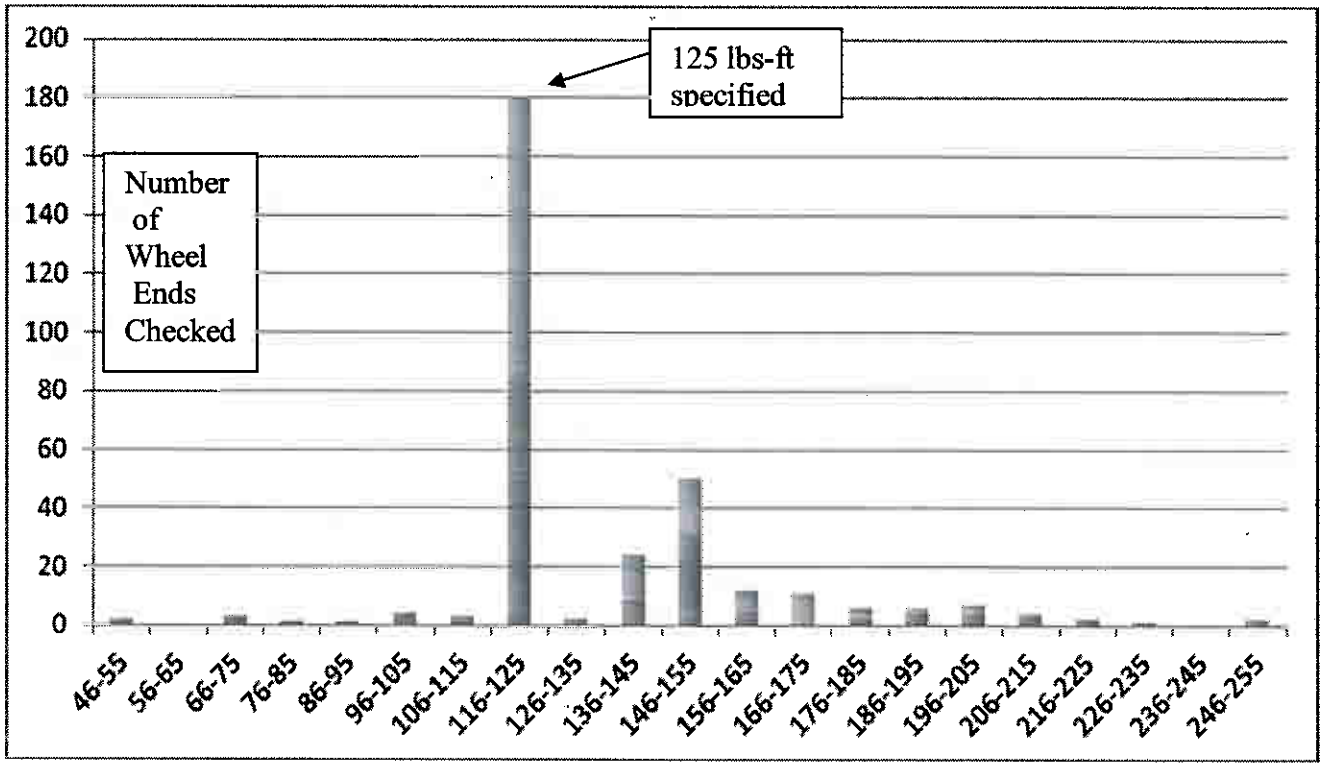
Date	Event
Sep 24, 2010	ODI initiates VOQ 10357608 & 10357608 based on reports of complete or partial wheel separations
Oct 14, 2010	ODI initiates PE10-040
Oct 28, 2010	ODI requests information from DRV
Nov 3, 2010	DRV advises ODI of a newly-reported wheel separation incident in a 2010 Mobile Suites RV near Jonesville, NC
Nov 22, 2010	DRV provides ODI with the information requested that ODI requested on October 28.
Dec 14, 2010	ODI, VRTC, and DRV personnel conducted a field inspection of the wheels ends – Incident no. 6.
December, 2010	DRV issued 1-page letter to owners reminding them to torque wheel nuts and report wheel end problems
Jan 18-25, 2011	DRV conducts survey of 47 DRV vehicles attending a rally (various vintages and models); found 5 vehicles exhibiting less than specified torque.
May 2, 2010	DRV advises ODI of a newly-reported wheel separation incident has occurred in a 2010 Elite Suites model DRV near Hutto, TX
May 5, 2011	ODI, DRV, and Kodiak (foundation brake supplier to DRV) personnel conducted a field inspection of the wheel ends – Incident no. 7
May 16, 2011	DRV initiates survey of in-service vehicles brought to the factory for repairs unrelated to wheel nut loosening. ODI initiates weekly review of survey data.
May 27, 2011	ODI upgrades investigation to EA11-007
June 18, 2011	DRV advises ODI of a newly-reported wheel separation incident in a 2011 DRV Mobile Suites Travel Trailer (at 7000 km) near Calgary, Alberta (9/16" stud). Incident no. 8.
June 30, 2011	Collision Analysis Associates inspects the June 18 incident vehicle as directed by Transport Canada
January 30, 2012	DRV announces Campaign 12V-028

EA11-007
Appendix E

Summary of Torque Checks Conducted on In-Service DRV Vehicles -

Summary of In-service Wheel Nut Torque Audit - 10Vehicles Equipped with 16" Wheels (9/16" stud)

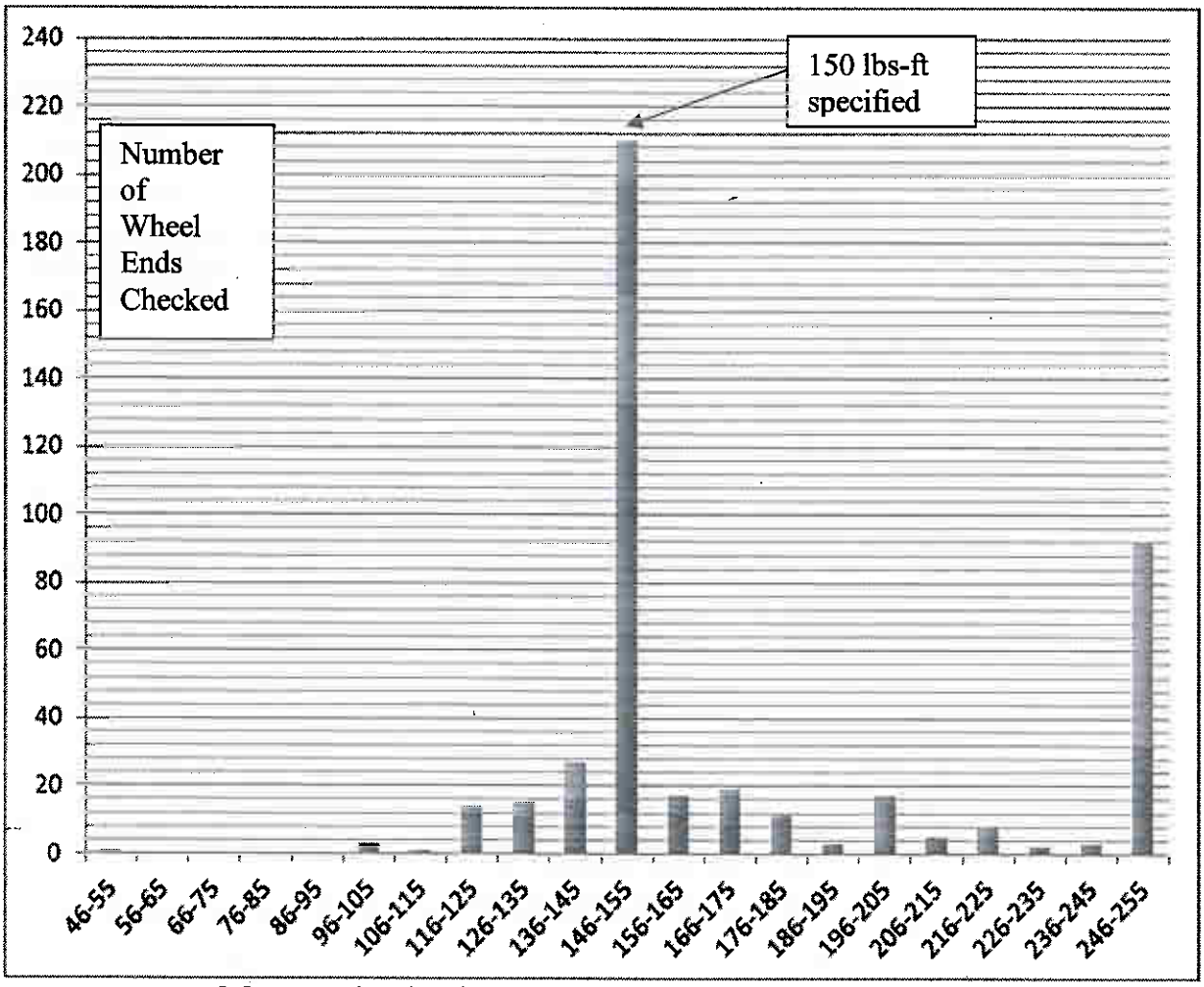
Measured Wheel Mounting Nut Torque



Measured Wheel Mounting Nut Torque Ranges (in lbs-ft)

13 wheel end nuts (4%) were measured at less than 115 lb-ft.
125 wheel end nuts (39%) were measured at more than 135 lb-ft.

Summary of In-service Wheel Nut Torque Audit – 14 Vehicles Equipped with 17-1/2" Wheels (5/8" stud)



Measured Wheel Mounting Nut Torque Ranges (lbs-ft)

33 wheel end nuts (7%) were measured at less than 135 lb-ft.
161 wheel end nuts (36%) were measured at more than 165 lb-ft.

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Appendix F

Industry Standards

During the course of this investigation, ODI referred to some of the following SAE standards:

- SAE J1102, Mechanical and Material Requirements of Wheel Bolts;
- SAE J1835, Fastener Hardware for Wheels for Demountable Rims;
- SAE J2316, Wheel Nut Seat System Test Procedures and Performance Requirements for Passenger Cars and Light Trucks;
- SAE J2315, Wheel Nut Seat Strength;
- SAE J1965, "Road Vehicles – Wheels for Commercial Vehicles and Multi-Purpose Passenger Vehicles – Fixing Nuts – Test Methods."

Note that SAE standards are generally consensus standards and not component specifications unless a particular manufacturer elects to adopt a specific standard as an element of their specifications.

The following SAE papers were also reviewed:

- 86-1974 (DOI: 10.4271/861974), "The Detachment of Wheels from Commercial Vehicles," John Searle (UK); [ODI note: this is a 25 year sold paper.]
- 2010-36-0472: Theoretical and Practical Studies for Designing the Effective Length of Threaded Fasteners, Considering the Applied Torque on the Joint;
- 82-0340 (DOI 10.4271/820340, "Wheel Attachment Design Considerations," Jon Parisen, General Motors.
- 2009-01-0111. "Mechanisms of Wheel Separations," (Mark Bailey, James Bertoch, MEA Forensic Engineers and Scientists) – have a copy.

ODI also referred to believes that the trailer industry consensus paper issued by the Trailer Safety Industry Coalition (TSIC) as Recommended Practices, December 20, 2004.