# Closing Report – EA04-016

## Steering Resistance, Binding, or "Lock-up" caused by a Broken, Bent, Deformed, Fragmented and/or Displaced Turn Signal Canceling Ring (TSCR) Installed in 1998 and 1999 Model Year Volvo Truck North America (VTNA) Heavy Truck Tractors

CONTENTS

**(1) Subject**

This Engineering Analysis, EA04-016, addresses the potential for the turn signal canceling ring (TSCR) installed in 1998-1999 model year Volvo Truck North America (VTNA) tractors to break, bend, deform, or fragment and to assess whether a TSCR that has been compromised by any of these failure modes could cause unexpected steering resistance, binding or "lock up" (increased steering effort).

For purposes of this report, ODI has adopted the abbreviation "TSCR" to identify the Turn Signal Canceling Ring.

To assure consumers' privacy, ODI has redacted the final six digits of all VINs listed in this report. ODI is maintaining the complete VIN information within the Agency as confidential information for potential future reference.

**(2) Background**

On June 14, 2002, ODI closed Preliminary Evaluation PE01-041 that had addressed claims of "steering lock-up, pulls, or binds" in model year 1998-2000 VTNA VN-410, 610, 660, 770 and STD (day cab) Series tractors. ODI's investigation had concluded that, "a safety related defect trend has not been identified ... [but] the agency reserves the right to take further action on the subject vehicles if warranted by the circumstances."

On December 11, 2003, Pro Transportation, Inc. contacted ODI and outlined their concern that certain vehicles had been in crashes and speculated that these vehicles may have experienced a steering wheel "lock" condition caused by the broken and/or deformed pieces of the "canceling cam" (i.e., the Turn Signal Canceling Ring). In light of this new information, ODI decided to take a "second look" at the performance of the Turn Signal Canceling Ring installed in 1998 and 1999 model year VTNA vehicles and determine whether the TSCR could have been a causal or contributing factor to the reports that alleged that certain drivers had encountered increased steering resistance in VTNA vehicles.

Pro Transportation also reported that drivers of similarly equipped 1998 and 1999 VTNA tractors had reported non-crash incidents in which the drivers had reported encountering unexpectedly high steering resistance. Pro Transportation was also aware that a significant number of the 1998 and 1999 VTNA tractors in their fleet had experienced a broken TSCR and postulated that the TSCR may have been a factor in the steering resistance encountered by the drivers.

Based on phone interviews with Pro Transportation representatives and a review of supporting documents, ODI prepared a summary (Appendix A) of the reported crash reports, driver reports, and a vehicle inspection conducted by VTNA personnel.

The crashes involving Pro Transportation vehicles occurred in 1998 and 1999, but ODI was not aware of them until Pro Transportation notified ODI late in 2003, approximately four to five years after the crashes had occurred. After being informed of these incidents, ODI made an attempt to locate these crash vehicles for possible inspection, but found it difficult to determine the whereabouts of these wrecked vehicles after the time that had elapsed since the crashes occurred.

ODI learned that Pro Transportation no longer owns any 1998 or 1999 model year VTNA vehicles so the Agency is not able to inspect candidate vehicles at Pro Transportation nor conduct any simulations of the effect that a broken, bent, deformed, or displaced TSCR may have on vehicle steering effort in fleet vehicles.

ODI asked Pro Transportation to provide samples of the TSCRs that Pro Transportation had removed from the fleet vehicles a few years earlier and made several phone follow-up calls regarding this request. Pro Transportation advised ODI that they had searched for these parts but had not been able to find any samples for ODI to inspect.

Although ODI did not have any physical evidence indicating that a broken TSCR could cause an unexpected increase in vehicle steering effort, ODI felt that the available information was sufficient to justify further investigation.

On February 5, 2004, ODI opened Preliminary Evaluation PE04-014 and sent an information request to VTNA. VTNA prepared a response dated March 25, 2004. VTNA provided ODI a signed and dated receipt indicating that the information had been delivered to the Department of Transportation on April 23, 2004. ODI conducted a search but has not been able to locate this information. ODI requested VTNA to re-submit the information and ODI received the requested information on May 18, 2004.

After ODI conducted an initial review of the information provided, ODI noted that the "date of vehicle production" information that VTNA had provided for the subject vehicles was not accurate. Certain dates for already-manufactured products had been reported as having been built at various future dates within the 2006 - 2012 time period. ODI contacted VTNA who ascribed the error to a data conversion problem from the VTNA electronic data format into the ODI-requested Microsoft Access format and sent corrected information.

On May 28, 2004, ODI contacted one of the fleets that VTNA identified as having a suspect TSCR (Watkins Motor Lines) to determine whether any of the 1998 or 1999 model year vehicles remained in Watkins Motor Lines fleet and/or whether Watkins Motor Lines' service records, driver complaints, service manager's recollections, or the like indicated any complaints, records of servicing, or problems of any kind with the TSCR. In response to ODI's request, Watkins Motor Lines advised ODI that none of Watkins tractors had been equipped with the self-canceling turn signal capability. On May 28, 2004, ODI notified VTNA of this information and asked VTNA to explain the apparent discrepancy.

On June 2, 2004, VTNA advised ODI that, by design, certain tractors (such as those purchased by Watkins Motor Lines) had been assembled with a TSCR installed but the turn signal switch assembly that was installed intentionally lacked the self-canceling capability. In other words, certain VTNA owners who did not specify a self-canceling turn signal feature may have a non-functioning (dummy) TSCR installed in their vehicle(s). VTNA also advised ODI that the initial list of affected vehicles identified all vehicles equipped with a TSCR whether or not the vehicle was equipped with the turn signal switch necessary to provide the self-canceling turn signal capability. VTNA agreed to send a revised list of vehicles that would identify (1) vehicles built with a TSCR in conjunction with a canceling turn signal assembly (by part number) necessary to provide the self-canceling turn signal capability and (2) vehicles built with a TSCR and assembled in conjunction with a turn signal switch that lacked the self-canceling turn signal capability.

On June 6, 2004, VTNA notified ODI that there were several (five or six) part numbers for the various turn signal switches that had been installed in conjunction with the three different TSCRs (identified by part numbers 1607363, 3176446, and 20379336). VTNA stated that they were not aware of the reasons for the part changes in the turn signal switch since VTNA's supplier had made the changes and, since these changes ostensibly affected only the internal mechanism of the turn signal switch, they did not affect VTNA's installation of the switch. In response, ODI requested VTNA to furnish ODI with information that identifies each VIN associated with each of the five or six turn signal switch assemblies in conjunction with each of the three TSCRs inasmuch as the performance of the turn signal switch assembly component could be interacting in some way with the TSCR and could therefore be a relevant consideration in this investigation.

On June 6, 2004, following a review of the information that VTNA had provided, ODI sent a supplementary list of questions to VTNA. VTNA provided a response (Appendix C) on June 22, 2004.

On September 7, 2004, ODI visited the FedEx Freight East terminal in Brook Park, Ohio and inspected four vehicles by removing the steering wheels from the candidate vehicles and inspecting and photographing the condition of the TSCR.

On September 11, 2004, ODI visited the FedEx Freight East terminal in Chester, Virginia and inspected and photographed the condition of the TSCRs in eight vehicles.

Appendix E provides a summary of these field inspections.

**(3) Population**

ODI initially focused this investigation on 1998 and 1999 model year "VN Series" VTNA tractors. During the investigation, VTNA advised ODI that VTNA had installed TSCRs with identical part numbers in certain VHD vehicle models. According to VTNA, VN Series vehicles are primarily intended for line-haul tractors whereas VHD Series vehicles are primarily intended for vocational service. Accordingly, ODI added VHD series vehicles to the population of subject vehicles.

According to VTNA, the self-canceling feature incorporating the "TSCR" was a buyer's option when the VN model was introduced in 1996. The standard turn signal system that VTNA offered did not have a self-canceling feature.

In addition, if a customer ordered the optional self-canceling turn signal feature and an optional driver's side air bag, VTNA installed an alternative turn signal canceling system that was incorporated into the air bag (that was mounted in the center of the steering wheel).

The table below summarizes the number of vehicles built with each of the Turn Signal Canceling Ring (TSCR) part numbers that VTNA installed in model year 1997-2004 vehicles.

| Model Years Installed | TSCR Part Number | Number of Vehicles Manufactured |
|---|---|---|
| 1997 - 2000 | 1607363 | 29,518 |
| 2000 - 2003 | 3176446 | 703 |
| 2003 - 2004 | 20379336 | 7,931 |
| Total | | 38,152 |

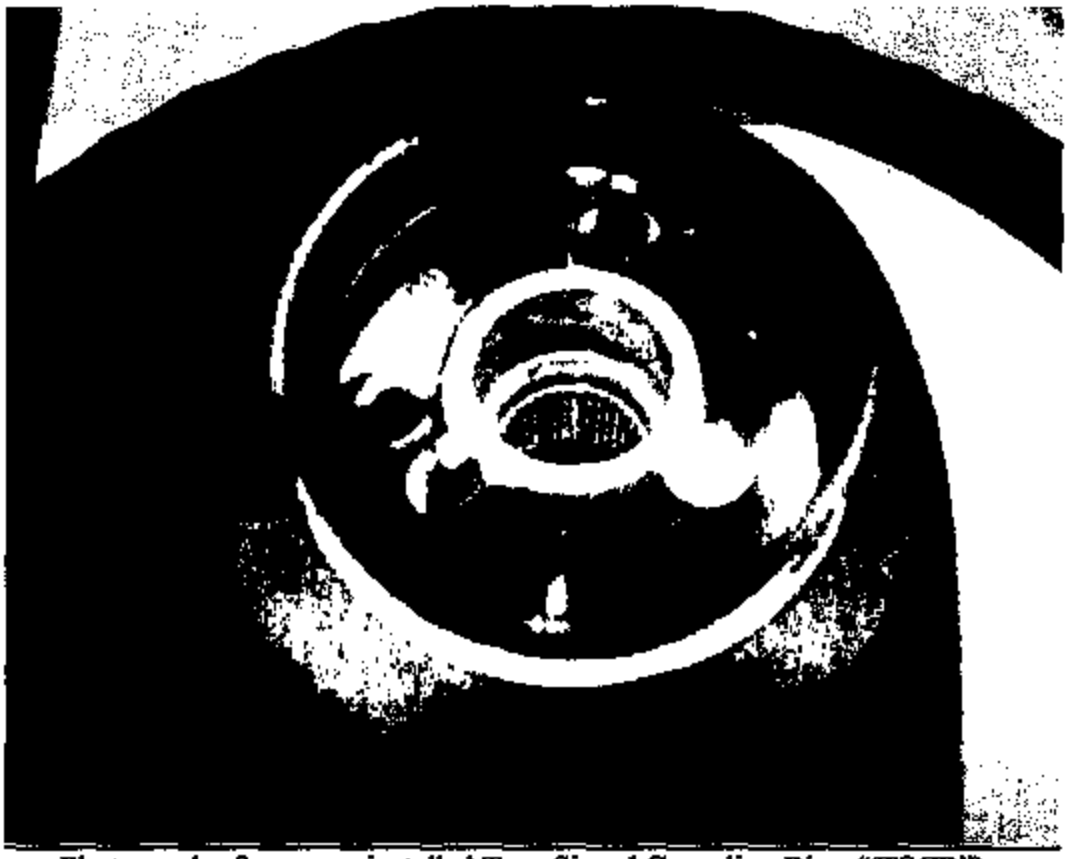
Establishing the Investigation Scope – This above-listed production data indicates that only TSCR part number 1607363 was installed in the 1998 and 1999 model year VTNA vehicles, the subject vehicles in this investigation. VTNA supplied more detailed production information that indicates that only a small quantity of TSCR 1607363 had been installed in 1997 and 2000 model year vehicles.

## (4) Product Description

TSCR #1607363 is a round molded black plastic component approximately 2-3/4" in outside diameter and 1/16" thick. The TSCR has a circumferential flange that stands outward at a right angle by approximately 1/2" from the body of the TSCR around the outermost circumference of the part.

TSCR #1607363 has an centered hole slightly larger than 1-1/4" in diameter which, when the TSCR is installed onto the steering wheel, fits over a raised steering wheel pilot which is approximately 1-1/4" in diameter and protrudes from the steering wheel back-face by approximately 1/8".

Photograph of a new uninstalled Turn Signal Canceling Ring ("TSCR"), VTNA part number #3176446. According to VTNA, TSCR part number #1607363 has been out of production since 2000 and samples are no longer available. TSCR #3176446 depicted above is similar in appearance to its predecessor TSCR #1607363, except for changes VTNA made to increase the strength of the two attachment legs near their base. Therefore, for general familiarization purposes, the photograph of TSCR #3176446 above provides a reasonable proxy for the appearance of TSCR #1607363.



Photograph of a new uninstalled Turn Signal Canceling Ring ("TSCR"), VTNA part number #3176446, installed onto the back-face of the VTNA steering wheel assembly. The two holes in the TSCR at approximately 3:00 and 9:00 o'clock positions indicate the positions of the legs that are retaining the TSCR to the steering wheel on the opposite (hidden) side of the TSCR. The bronze colored components that protrude through the "cut outs" in the TSCR are the electrical leads for the horn.

The TSCR is retained to the back face of the steering wheel hub by two protruding plastic "retaining legs" that are approximately 3/8" in diameter and approximately 1/2" long which are molded integrally into the plastic TSCR. When installed onto the back-face of the steering wheel hub, the attachment legs of the TSCR seat in two approximately 3/8" bores in the steering wheel hub located at the 12:00 o'clock and 6:00 o'clock positions.

Each of the TSCR mounting legs is manufactured with three equally spaced lengthwise tapered "splits" that extend for almost all of the leg length. These "splits" permit each of the three retention leg segments to deflect inwardly during installation so that the legs can be inserted into their respective host bores in the back face of the steering wheel hub.

A shoulder or "ledge" is molded into each plastic leg on the outside diameter at the extremities (or tips) of each of the three leg segments of the two retention legs. After the TSCR has been fully seated in the host bores of the steering wheel hub, the attachment legs that had been deflected inwardly, tend to return (elastically) to their pre-installed form forcing the shoulders molded into the tips of the TSCR legs to lock against a shoulder molded into the bore of the cast aluminum steering wheel hub thus securing the TSCR to the steering wheel.

The face of the TSCR that mounts against the steering wheel hub is provided with two cutouts (at 4:00 o'clock and 11:00 o'clock position when viewed from the back of the steering wheel) that provide a routing path for the steering wheel horn contact brushes to contact the steering wheel horn ring.

The TSCR can only be installed in one orientation relative to the steering wheel due to the placement of the two retention legs and the two horn ring cutouts on the TSCR.

A 3 /4" long circumferential tab ("canceling tab") that extends outward (in the direction of the steering column) by approximately 1/2" is integrally molded into the circumference flange of the TSCR.

When the turn signal is actuated, the "tongue" extends (is displaced outwardly) into the path of the arc "swept" by the TSCR "canceling tab" (described above). When the steering wheel is turned in the direction that has been indicated (signaled) by the turn signal switch, negligible steering effort is required for the TSCR tab to displace the turn signal switch tongue from the path swept by the TSCR canceling tab. When the steering wheel is returned in the direction opposing the direction that is indicated (signaled) by the turn signal switch, a slightly greater steering effort is required to displace (or "trip") the extended turn signal tongue from the path of the TSCR canceling tab, thus canceling the turn signal.

When the extended turn signal "tongue" has been displaced (or "tripped") by contact with the TSCR canceling tab, the turn signal is cancelled and the turn signal handle is returned to its "at-rest" or non-signaling position.

VTNA furnished ODI measured values of steering effort required to "cancel/overpower" the flasher during investigation EA02-021. ODI has summarized these previously measured values in Section 6, Paragraph D, "ODI Investigation."

## (5) Product Changes

According to VTNA, the following changes have been made to the turn signal canceling ring in the subject vehicles:

| Date | Part Number | Description of Change | Reason for Change |
|---|---|---|---|
| Jan 4, 1999 | 1607363 | "revised" | "assembly problems" |
| Nov 22, 1999 | 3176446 | "replaced Part Number 1607363" | "problems with the plugs on the rings breaking, caused by fatigue. This makes the ring loosen from its position." |
| Nov, 2002 | 20379336 | "new design" | "associated with the release of a different steering column design." |

Source: VTNA.

## (6) ODI Investigation

PE04-014

During the Preliminary Evaluation, PE04-014, conducted between February 5, 2003, and June 24, 2004, ODI had not been able to inspect candidate vehicles, obtain samples of the failed TSCRs, nor review any photographs that depicted the broken, bent, deformed, fragmented and/or displaced condition that had been described in various complaints, warranty claims, and documents that were available at that time. ODI's review of the information available during the Preliminary Evaluation provided indications that a potential safety issue could exist. This information is summarized in paragraphs (1), (2), and (3) below and was sufficiently compelling to prompt ODI to open Engineering Analysis EA04-016.

EA04-016

Other than supplementary information provided in June 2004 (Appendix C), ODI did not request VTNA to provide any additional information during EA04-016 conducted between June 2004, and February 2005 because ODI was primarily concerned about determining the failure modes and assessing the potential effects associated with a "failed" TSCR and VTNA had already exhausted their available information regarding these issues. During EA04-016, ODI was able to locate and inspect twelve vehicles equipped with the suspect TSCR and to conduct simulations intended to assess the effect that a broken, bent, deformed, fragmented and/or displaced TSCR could have on vehicle steering effort. These Engineering Analysis investigation activities are summarized in paragraphs (4) and (5) below.

ODI conducted the following investigation activities:

(1) Reviewed Previously Closed (Completed) ODI Investigations -

ODI reviewed previous investigations pertaining to VTNA vehicles in which drivers had alleged that the control of VTNA tractors had been compromised. These prior investigations addressed front suspension U-bolts (EA02-021) and Steering Gearbox or [Steering Shaft] U-Joint Failures (PE01-041).

In EA02-021, ODI concluded that, "the front suspension U-bolts had not been factors in causing these crashes." In PE01-041, ODI concluded that, "a safety-related defect trend has not been identified ... " Appendix D summarizes ODI's review of these completed investigations.

(2) Reviewed Vehicle Owner Questionnaires (VOQ)

ODI researched potentially relevant VOQs to identify owner complaints that indicated steering resistance, binding or lock-up in the subject vehicles. ODI has not received any additional reports that appear to be relevant to this issue since May 2002 (VOQ 565634 listed below).

The following table summarizes relevant VOQ complaints. Since the turn signal canceling ring had been installed in only a portion of the vehicles that VTNA built, ODI researched the VIN data provided by VTNA to determine whether or not the VOQ complaint vehicle had been equipped with a turn signal canceling ring. ODI provided that information in the right-most column of the following table.

Summary of VOQ Indicating a Potential Steering Issue in VTNA Tractors

| VOQ (Date Rec'd) | Vehicle Description in VOQ | VOQ Verbatim Complaint | Vehicle Built with Turn Signal Canceling Ring? (Vehicle Build Date) |
|---|---|---|---|
| 550207 (1/4/2000) | 1999 VN770<br><br>VIN - 4VG7DAR J3XNXXXX XX | "when turning left the steering wheel does not return because the return mechanism in the t/s switch was out of place." | Yes<br><br>(8/31/98) |
| 549610 (9/1/98) | 1998 VN770<br><br>VIN – 4VG7DARJ 3WNXXXX XX | "steering wheel locked up almost resulting in an accident." | Yes<br><br>(2/2/98) |
| 565201 (8/15/2001) | 1998 VN610<br><br>No VIN provided | "consumer states that steering locked up." | Unknown<br><br>(No VIN provided) |
| 565028 (8/15/2001) | 1998 VNL64T<br><br>VIN 4VG7VACK 2WNXXXX XX | "consumer states that steering was inoperative." | Yes<br><br>(1/9/97) |
| 565634 (5/13/2002) | 1999 VNL 4VG7VAJH 8XNXXXX XX | "consumer states the steering wheel locked up" | No<br><br>(Unknown) |
| 565015 (8/15/2001) | 2000 VN<br><br>No VIN provided | "while driving the steering locked and the vehicle veered right crashing into a guardrail, totaling the vehicle." | Unknown<br><br>(No VIN provided) |

(3) VTNA Information in Response to Information Requested in PE04-014 -

ODI requested and reviewed the Preliminary Evaluation (PE04-014) information from VTNA and, using this information, conducted further investigation of the following topics.

(A) Survey of Major Fleet Users -

ODI prepared a list of the major fleet purchasers of VTNA tractors equipped with a TSCR with the intention of contacting a number of these purchasers to determine whether or not the fleet's service records indicated any concern and/or whether the fleet was aware of any incidents that might be associated with a malfunctioning or broken turn signal canceling ring (TSCR). ODI also intended to identify those fleets that were currently operating any VTNA tractors equipped with a suspect TSCR, identify the whereabouts of these vehicles, and, where practical, to conduct a field inspection of the TSCRs installed in these tractors.

To facilitate the identification of candidate vehicles, ODI planned to furnish each of the candidate fleets with a list of TSCR-equipped VINs so that fleets would be able to review their service and accident records and identify the appropriate vehicles.

The first fleet that ODI contacted reported that their vehicles had not been equipped with self-canceling turn signal capability. In light of this response, ODI asked VTNA to review the accuracy of the information provided to ODI and the reason for any misunderstanding with the fleet regarding this presence or absence of the self- canceling capability. VTNA investigated the issue and advised ODI that the originally supplied list was accurate and that approximately 38,152 vehicles had been equipped with the suspect turn signal canceling ring (TSCR #1607363) but that only approximately 16,000 of these vehicles had been equipped with the self-canceling turn signal switch assembly needed to provide the self-canceling capability.

(B) Review of VTNA Field Reports -

VTNA provided copies of seventeen field reports. Thirteen reports were obtained from VTNA's "Siebel" Field Report System. Four reports came from VTNA's "Customer Contact Report" database. VTNA used the "Customer Contact" database to store and retrieve their field report information prior to using the current "Siebel" System.

(a) Customer Contact Report database. Following is a summary of three relevant "customer contact reports." The fourth report (#24688) does not appear to provide information that is relevant to this investigation. (In response to ODI inquiry, VTNA advised that Report # 24688 had been included in error and is therefore not included in this summary.)

| Report Number | Date | Vehicle s/n | Verbatim Excerpt |
|---|---|---|---|
| 25326 | Sept 25, 1998 | 760520 | ... The tab that canceles [sic] the turn signal B [sic] brakes [sic] off. This has resulted in the broken tab getting lodged in the tube. This tab is plastic it brakes [sic] up as the wheel is turned back and forth.... |
| 26054 | Nov 2, 1998 | 778875 | ... truck had run off road with loaded trailer full of meat. Driver claimed steering failure...one concern was that turn signal selfcanceler [sic] had broken and jammed the steering wheel. Review truck for any sign of failed axle or steering component and found none. Then removed steering shaft from gear and turned to see if any bind at wheel. Then set turn switch in both directions and no bind from wheel... |

| | | | |
|---|---|---|---|
| 29353 | April 26, 1999 | 773873 | ... signal canceling cups. These plastic cups have broken and caused interference in steering column. Customer not comfortable with cup in place, and is removing them (the result is that the turn signal is now non-canceling)... |

(b) Siebel System - None of the thirteen reports obtained through the Siebel Report System addressed broken or deformed TSCRs. All of the reports relate to loss of the turn signal canceling function in 2003 and 2004 model year tractors. Some of the reports describe an excessive steering wheel endplay condition that had allowed the TSCR canceling tab to fail to contact the turn signal switch "tongue."

The model year 2003 and 2004 VTNA tractors addressed in these Siebel System reports are outside the direct scope of this investigation since 2003 and 2004 model year VTNA tractors were equipped with a different turn signal canceling ring (part number 20379336) than the TSCRs that are the focus of this investigation (1607363) and which were installed only in 1997 – 2000 model year VTNA tractors.

(C) Review of VTNA Warranty Claims

ODI reviewed the 183 VTNA warranty claims pertaining to steering system complaints that VTNA provided in response to ODI's request for warranty complaints that "relate to, or may relate to, the alleged defect." Of the 183 warranty claims provided, ODI identified 146 that appeared to be directly related to a malfunction of the turn signal canceling ring.

ODI analyzed these 146 warranty complaints and grouped them according to the symptom described (i.e., the basis or symptom for which the operator determined the need to have the vehicle serviced) in the narrative of the reports. The following table summarizes the results of this analysis.

| Symptom Described | Number of Reports |
|---|---|
| Turn Signal Does Not Cancel | 62 |
| Noise | 40 |
| Horn not working or horn actuates when the steering wheel is turned | 20 |
| Steering Binds | 13 |
| Pieces of plastic found | 2 |
| Turn Signal Doesn't work | 2 |
| No Symptom Provided | 7 |
| Total | 146 |

The following table summarizes each of the thirteen warranty reports that indicate that the steering effort may have been adversely affected. The descriptions in these warranty claims provide limited information about the specific cause but generally indicate that the steering had been resistive, binding, or "locked."

| ODI No. ------ VTNA Claim No. | VIN (redacted) | Date of Repair | Mileage | Verbatim Comments from VTNA Warranty Claims |
|---|---|---|---|---|
| #1 007866 | 4VG7DAG HXWNXX XXXX | 20-Apr-98 | 83535 | CK.STEERING LOCKING UP.T/S,JACK UP FRT.END&TURN WHEEL,FOUND CLICKING COMING WHEEL.REM.UPPER&LOW ER COLUMN&INSP.,OK.REM.WHEEL,FOUND T/SIG.ACT.& HORN RING BROKEN.REPL.REASS.&LINE UP WHEEL,OP,O TURN |
| #2 026162 | 4VG7DARJ 2WNXXXX XX | 14-Jul-98 | 67262 | STEERING WHEEL LOCKED UP.FLASHER BROKE,A PIECE FELL DOWN INTO STEER WHEEL,CAUSING IT TO BIND,RESULTING IN DAMAGE.REPLACE STEER WHEEL AND FLASHER. |
| #3 981706 | 4VG7DBJH 2WNXXXX XX | 25-Aug-98 | 14069 | REPAIR STEERING WHEEL STICKS WHEN TURNING LEFT. TROUBLESHOOT. FOUND FLASHER RETAINER BROKEN AND BINDING REPLACE FLASHER |
| #4 035090 | 4VG7DAR H6WNXXX XXX | 18-Sep-98 | 57967 | CK.STEERING COLUMN,LOCKS WHEN TURNING. CAUSE: CANCEL RING FORTURN SIGNAL BROKEN. R&R RING. |

| | | | | |
|---|---|---|---|---|
| #5<br>982162 | 4VG7DAG<br>H1WNXXX<br>XXX | 21-Oct-98 | 11686 | STEERING WHEEL BINDS. REMOVE STEERING WHEEL AND FOUND FLASHER CUT OUT BROKEN. REMOVE AND REPLACE. INSTALL STEERING WHEEL AND RECHECK . IS NOT BINDING. PROBLEM CORRECTED. |
| #6<br>320344 | 4VG7DAJJ0<br>WNXXXX<br>XX | 02-Dec-98 | 55341 | STEERING BINDING. FOUND SMALL PLASTIC PIECES IN COLUMN. OVER TIGHTENED FROM FACTORY. REPLACED STEERING COLAR. |
| #7<br>179532 | 4VG7DBG<br>H4WNXXX<br>XXX | 09-Feb-99 | 74015 | CLICKING NOISE FROM STEERING WHEEL AND WHEEL WANTS TO BIND AT TIMES. CANCELLING CONTROL BROKEN. REPLACED CANCELLING CABLE |
| #8<br>013341 | 4VG7DBRJ<br>4XNXXXX<br>XX | 08-Jun-99 | 78354 | STEERING JAMS INTERMITTENTLY & WHEN FORCED -CRUNCHING NOISE.R&RWHEEL &FIND FLASHER RESET CAM BRKN.CLEAN OUT PIECES &REPLACE PARTS. |
| #9<br>186185 | 4VG7DAG<br>H1XNXXX<br>XXX | 28-Jun-99 | 65104 | STEERING HANGS WHEN TURNING TURN SIGNAL CAN CAM BROKEN REPLACED SSIGNAL CANCEL DEVICE |
| #10<br>015649 | 4VG7DAJF<br>9XNXXXX<br>XX | 20-Jul-99 | 110179 | STRG WHEEL STICKS/T/SIG SELF CANCEL BRAKE OFF/REPL T/SIG SELF CANCEL |
| #11<br>506270 | 4V4MD2RF<br>XYNXXXX<br>XX | 25-Oct-99 | 17145 | STEERING ROUGH AT TIMES. FOUND DUST COVER & 2 ELECTRIC LEADS BROKEN. R/R COVER & LEADS. REINSTALL WHEEL. REMOVED COLUMN CVR TO REMOVE BROKEN CHIPS THAT FELL IN IT. TEST DROVE, TESTED OK |
| #12<br>019425 | 4VG7DBJH<br>5XNXXXX<br>XX | 01-Mar-00 | 88821 | STEERING WHEEL JAMS WHEN TURNING.FIND CANCELLATION RING FOR SIGNAL BROKEN.REPLACE RING |
| #13<br>002440 | 4VG7DARJ<br>XXNXXXX<br>XX | ######## | 164832 | STEERING LOCKS WHEN TURNING. TURN SIGNAL KICKER BROKEN. CHK ALL RELATED STEERING COMPONENTS, OK. CHK P/S PRESSURES,OK. FND T/S KICK OFF BROKEN. R&R AND RECHK, OK. |

An additional 20 warranty claims (not summarized) reported the vehicle "city horn" (mounted within the steering wheel hub proximate to the TSCR) was rendered inoperative or had unintentionally sounded when the steering wheel was turned. The TSCR was replaced as part of these repairs, indicating that some or all of the TSCRs were able to move out of their intended position and affect the electrical contacts for the horn.

(4) ODI Field Inspections

In order to obtain a clearer understanding of the frequency, nature and likely effects of a "failed" TSCR, ODI reviewed the list of fleets that purchased vehicle equipped with suspect TSCR part number 1607363. ODI selected candidate fleets based on the number of tractors equipped with the suspect TSCR originally purchased by the candidate fleet and, as determined by telephone inquiries with those fleets, the number of candidate vehicles that were still in active service at the candidate fleets, the concentration of the candidate vehicles at a single point of inspection (i.e., at a single fleet terminal or depot) and accessibility to ODI personnel. After several inquiries with various fleets, many of which no longer owned the candidate 1998 and 1999 model year vehicles, ODI contacted Federal Express East and arranged to inspect vehicles at terminals in Brook Park, Ohio (near Cleveland) and Chester, Virginia (near Richmond).

These vehicle inspections found that a significant majority (75 %) of the TSCRs installed in the inspected vehicles exhibited one or more cracked or broken TSCR retaining legs.

Summary of 1998 and 1999 Model Year VTNA Fleet
Vehicle Inspections Conducted in September 2004

| Location | Number of Vehicles Inspected | Number of Vehicles Found with one or more retaining legs broken from the TSCR |
|---|---|---|
| Brook Park, OH | 4 | 4 |
| Chester, VA | 8 | * 5 |

* After removal, ODI found at least one TSCR retaining leg installed in an additional three vehicles was cracked. ODI may have cracked these TSCR retaining legs when removing the TSCR from the steering wheel hub.

The inspection also found that the separated portion of the retaining legs from broken TSCRs that ODI inspected (See Appendix E) are of negligible

weight and small in size measuring approximately 0.3" to 0.4" in length, approximately .25" wide and are approximately .015" thick through the concave-convex profile of the leg.

A short "stump" measuring approximately 0.1" to 0.2" in height remained attached to the main body of all of the broken TSCRs that ODI inspected (i.e., the retaining legs did not break flush with the TSCR surface.)

The following photograph depicts a representative TSCR in situ in inspected vehicle s/n 755949. A more comprehensive summary of the inspection observations and photographs notes is provided in Attachment E. Additional photographs are in the investigation file.

Photograph of TSCR in its installed position with the steering wheel removed.

The steering wheel is mounted on the steering shaft splines shown in the left side of the photograph. The TSCR is mounted over the steering shaft and retained to the back face of the steering wheel by the two retention legs. The TSCR depicted above was found separated from the steering wheel hub because four (of the six possible) retention leg segments had fractured. At inspection, one of the separated retention leg segments was found lodged against the steering shaft as shown above.

(5) ODI Simulation Exercises

With the exception of one TSCR that ODI left at Federal Express East, ODI labeled and transported the removed TSCRs to ODI's Washington offices.

ODI installed some of the "failed" TSCRs (i.e., those with one or more broken legs) in a "mock-up" of the VTNA steering wheel and shaft assembly that VTNA had previously provided at ODI's request. ODI then assessed the effect of the "failed" TSCRs on steering effort.

The objective of the simulation was to evaluate whether there appeared to be any conditions or circumstance under which a "broken, bent, deformed, or displaced piece of a TSCR" might be able to fall or wedge in some portion of the steering wheel and shaft mechanism and obstruct, interfere, and/or possibly "jam" the steering wheel significantly and thereby cause a significant and unexpected increase in steering effort.

ODI observed that the legs that had broken from the TSCR are small and light and generally appear incapable of imposing any significant effect on steering effort unless positioned in a wedging or jamming position. ODI made numerous attempts to place a separated portion of the retaining leg in a position that appeared likely impede the steering effort (e.g., abutting the oscillating movement of the steering shaft, positioned within the horn-contact through-holes, and into various recesses in the horn contact ring). ODI found that the effect of the displaced TSCR and/or broken pieces of the TSCR was negligible in each of the simulations attempted.

Photograph showing the broken and separated TSCR retention legs removed from FedEx East vehicle unit # 3078. The broken leg pieces exhibit small nicks and abrasions. The penny provides a reference that indicates the size of the broken leg pieces.

In several trials, the small separated piece(s) of the retention legs were promptly ejected from (fell from) the steering wheel assembly. This outcome is consistent with VTNA warranty and field reports that reported finding small pieces of the TSCR that had fallen from the steering assembly.

ODI placed a piece of the fractured leg in the TSCR through-hole provided for the horn electrical contact. The broken leg segment remained in position beneath the horn electrical contact lead as the steering wheel was turned (oscillated). This positioning would have interrupted the electrical contact to the horn when the horn switch was activated. This simulation is consistent with the warranty and field reports that had reported finding a broken TSCR when investigating the reasons for a non-functioning "city horn."

ODI broke all of the three leg segments from a single retention leg to determine whether the partially secured TSCR could shift, lodge, or wedge in a position that might increase steering when not completely retained by both retention legs. ODI found that the TSCR was able to partially detach from the back face of the steering wheel but was restrained from significant displacement by (1) a pilot on the back face of the hub that fit into the inner diameter of the TSCR; (2) the steering shaft that passes through the center of the TSCR; and (3) the horn electrical contact leads that protrude through the cut-outs provided for them in the TSCR. The horn electrical contact leads contacted the edges of the TSCR cutouts when the TSCR was shifted (rotated) more than approximately 1/8" from its installed position. The broken TSCR could be displaced (rotated) within a small circumferential arc but was limited from any greater displacement by the remaining intact retention leg and by contact of the TSCR with the host pilot diameter provided in the steering wheel hub.

ODI notes that the TSCR is made of a plastic material and that the separated retention legs are smooth with few surface interruptions or irregularities, offering little opportunity to snag or grip. (The portion of the leg most likely to grip or snag is the circumferential protrusion or bulge molded into at the tip of the leg to retain the leg in the steering wheel bore. However, this "grip" is more rounded than sharp and appears to provide negligible capability to grip or snag.)

Since the broken pieces of the leg are small, it appears that a piece of a broken retention leg would tend to repose in a harmless position, most likely at the base of the host steering wheel hub bore (where ODI found the majority of the separated legs during inspections).

## (7) ODI Assessment

ODI initiated Preliminary Evaluation. PE04-014, based on a concern that the TSCR might bend, deform, break, and/or be displaced and create a resistance or binding in the steering wheel effort.

Based on the (1) warranty claim and complaint information, (2) the changes that VTNA made to strengthen the retention legs of TSCR #1607363 in November 22, 1999, after less than one year of product use (as summarized in the table below), and (3) the result of ODI field inspections indicating that the retaining legs have broken or cracked in a significant majority of the vehicles inspected after approximately five years of service, ODI has concluded that a significant majority of one or both of the TSCR retention legs installed in 1998 and 1999 model year VTNA tractors are likely to break or crack and/or have already broken or cracked.

Summary of Information Indicating TSCR #1607363
Retention Legs may Break or Crack

| Source | Number of Indicating TSCR | Description |
|---|---|---|
| VTNA Warranty | 146 | 13 warranty claims alleging various degrees of steering resistance associated with the TSCR |
| ODI VOQ | 3 | 3 consumer complaints alleging steering was either "inoperative" or "locked up" |
| Field Reports | | 1 alleging "interference in steering column" |
| VTNA Product Change | | "problems with the plugs on the rings breaking, caused by fatigue. This makes the ring loosen from its position." |

During the field inspection, ODI noted that the majority of the fractured retention legs were retained harmlessly in the host steering wheel mounting bores.

ODI's field inspection also found that pieces of a broken TSCR retention leg could migrate into unexpected positions in the steering wheel assembly.

(1) In vehicle VIN s/n 755949, the separated portion of the retention leg had positioned itself into the area between the steering shaft and the TSCR.

(2) In vehicle VIN s/n 755969, the separated portion of the retention leg had positioned itself in the horn electrical contact access "pocket" or "cut-out" in the TSCR.

(3) In vehicle VIN s/n 750736, the separated portion of the retention leg had lodged between the TSCR and the horn contact ring.

In light of these observations, ODI attempted to position a separated retention leg in various positions of the steering wheel assembly. None of the various orientations and locations that were simulated appeared to indicate that the steering effort was increased or affected in any way.

During these field inspections, ODI observed that TSCRs that exhibited one or more broken retention legs were easy to remove from the steering wheel since the remaining intact retention legs provided significantly less retention force than a TSCR with intact retention legs.

When attempting to remove TSCRs that appeared to have intact retention legs, ODI's inspecting engineer heard a distinct audible sound of a "crack" indicating that a leg had broken during the attempted removal. This observation indicates that intact TSCRs cannot be removed easily without cracking or breaking the retention legs. Therefore, it appears to be prudent to leave the currently installed TSCRs in place rather than attempt to remove them since removing TSCRs risks displacing otherwise innocuous cracked or broken retention legs and/or cracking or breaking the retention leg(s) on an undamaged TSCR.

If fleets or vehicle owners decide to remove a broken TSCR or replace an apparently intact TSCR, ODI recommends that the servicing technician carefully inspect the area of, and proximate to, the steering wheel hub to assure that there are no broken TSCR pieces that may migrate into nearby areas of the steering system, such as the steering wheel horn electrical contact area where the separated piece may position itself where it interrupts the electrical contacts to the horn contact ring and compromises the "city horn" function.

## (8) Conclusions

This investigation is closed.

Though ODI's field inspection consisted of only twelve vehicles, the findings of these inspections in conjunction with warranty and field report information lead ODI to believe that the failure rate of the VTNA TSCR #1607393 retention legs installed in 1998 and 1999 VTNA tractors after five years of field exposure is high. Nine of the twelve vehicles equipped with a TSCR that that ODI inspected after approximately five years of field exposure exhibited one or more broken and/or separated TSCR retention leg(s). Suspect TSCR #1603737 has not been installed in VTNA vehicles since being replaced by TSCR #3176446 early in model year 2000. TSCR #3176446 incorporates ribs at the base of each retention leg to reduce/eliminate retention leg breakage.

ODI also observed that the broken pieces of TSCR retention leg are small and unlikely to cause or contribute to an increase in steering effort. ODI was not able to simulate any position within the steering wheel assembly in which the fractured and separated TSCR retention leg piece(s) and/or unsecured and displaced TSCR might cause or contribute to a significant increase in steering effort.

ODI suggests that owners take no action on the TSCR #1603737 installed in 1998 and 1999 model year VTNA vehicles. If owners or fleets attempt to remove TSCR #1607393 for any type of servicing, ODI cautions the servicing technician to carefully inspect and remove any broken pieces from the TSCR and/or other debris from the steering wheel assembly, especially in the area surrounding the TSCR.

ODI has determined that a safety-related defect trend has not been identified at this time 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. The agency reserves the right to take further action if warranted by the circumstances.

G. T. Bowman, Safety Defects Engineer

3/31/05
Date

I Concur:

Richard Boyd — 3/30/05

Chief, Medium & Heavy Duty Truck Division — Date

[signature] — 3/30/05

Director, Office of Defect Investigation — Date

**EA04-016**
**Appendix A**
**Sheet 1 of 1**

Summary of Crashes and Complaints Reported by Pro Transportation, Inc.

| Date of Occur-rence | Incident - Severity | First 11 digits of VIN | Reference Documents | Description |
|---|---|---|---|---|
| 3/98 | Driver Report | 4DG7DA RF2WN ..... | | Driver complained that steering locked. |
| 4/5/98 | Crash | 4VG7DA RF6WN ..... Unit # 134 | Ins CK 0030413222H002 | Tractor pulled to left and overturned. |
| 5/26/98 | Crash Fatality | 4VG7DA RF9WN ..... | Nevada Police Rpt R1998-001363 | VTNA tractor jerked to left, vehicle rolled, struck by another passenger car (fatality). |
| 5/26/98 | | 4VG7DA RF4WN ..... | Insurance: St Paul CK003 041 32-13 A-002 | VTNA tractor "shot" left allegedly due to strg "locked." Tractor rolled, VTNA passenger injured. |
| 5/28/98 | Volvo Inspection | 4DG7DA RF8WN ..... Unit # 135 | | VTNA engineers inspected a representative vehicle, no problem found. |
| Fall – Winter /98 | Driver Report | | | Reported that vehicle could not turn found pieces of black plastic on cab floor – found to be pcs of "signal canceller." |
| 12/19/99 | Crash Triple Fatality | 4DG7DE RHOXN ..... Unit # 294 | | VTNA tractor driver was crossing bridge (shortly after 8 hr rest) and went to left toward median into oncoming lane crashing head-on into oncoming tractor operated by Gainey Trans killing VTNA tractor driver and two occupants in oncoming tractor. |

**EA04-016**
**Appendix B**
**Sheet 1 of 1**

**Summary of Incidents from ODI Investigation, EA02-021, that indicated the vehicle operator lost control (departing the roadway) with no specific cause identified**

Since the cause of these loss-of-control incidents had not been conclusively established in ODI's investigation EA02-021, ODI compared the VINs identifying the crash vehicles to the VINs identifying vehicles equipped with the turn signal canceling ring (TSCR) #1607363 that is the subject of this investigation. The VIN comparison indicated that none of the vehicles investigated in EA02-021 had been equipped with a TSCR of any part number.

| VIN (redacted)/ Investigation Source | Incident Information | Incident Description |
|---|---|---|
| 4V4ND1GH4YN XXXXXX<br><br>EA02-021 | July 3, 2001 Cocke County, Tennessee. | Post incident photographs taken on-site and witness accounts indicate that the vehicle departed the roadway to the left, through the median, across the oncoming lanes, and into and through the opposite lane guardrail. |
| 4V4NC9JH91N XXXXXX<br><br>EA02-021 | October 16, 2002 Deming, NM | "(the witnesses) ... had been eastbound in the left lane traveling at 65 MPH when the tractor-trailer passed them in the left lane . The tractor-trailer the (sic) then changed lanes into the left lane in front of them. The tractor-trailer then suddenly went in to (sic) the median and overturned...there was no traffic in front of the tractor-trailer before it went into the median..." |
| 4VG7DBRJ7XH XXXXXX<br><br>EA02-021 | April 3, 2002 Beaver, Utah | The driver said that he "felt like he hit a rut" and that "the vehicle took off to the left." According to the driver, the tractor departed the roadway to the left, went through the median area, and rolled to the right when ascending the median in the direction of the oncoming lane of traffic. |

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**Volvo Trucks North America, Inc.**

June 22, 2004

**VIA EXPRESS MAIL**

Mr. Tom Bowman
Medium & Heavy Duty Vehicle Division
Office of Defects Investigation
U.S. Department of Transportation
National Highway Traffic Safety Administration
400 Seventh Street, S.W.
Washington, DC 20590

Re: **NVS-214gtb**
**PE04-014**

Dear Mr. Bowman:

The following is in response to your email of June 3, 2004.

**Question 1:**

(1) What are the various maneuvers described in the Bar Chart titled "Flasher reset measurements?" i.e. what is "to break reset," "to break brushes," etc. Since the TSCR and the horn brushes turn as a unit, how did this test apply a force into the brushes? How could the force to "break the brushes" have been so low (compared to other forces measured)? What was the outcome for the "break the brush" portion of the test? Did the brushes retract? or bend? or shear? or pull through? etc

**Response:**

The engineer who performed the test is no longer with the company. In speaking with persons who were aware of the test, information has been gathered concerning its performance and results.

It was first noted during the assembly process that a portion of the covering on the steering wheel intruded into the area where the TSCR was located. This prevented the TSCR from properly seating. About the same time, reports in the form of warranty claims were being received indicating excessive parts breakage.

An evaluation indicated the failure was most likely due to the improper seating condition creating a bending load on the insertion pins. When one pin broke, the TSCR was capable of

**Volvo Trucks North America, Inc.**
7900 National Service Rd. (27409)
PO Box 26115
Greensboro, NC 27402-6115

**Telephone**
(336) 393-2000

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rotating about the other insertion pin. This could possibly cause the TSCR to shear the horn contacts which are ceramic and therefore rather brittle.

Efforts were made to duplicate field complaints in the engineering department by mocking up a steering wheel and improperly seated TSCR and rotating the wheel through numerous cycles. No failures or breakages were experienced.

A screwdriver was then inserted into the housing thereby "locking" the TSCR in position. A torque wrench was then used to apply rotational force into the steering column. Under this scenario, breakage of the insertion pin and horn contact could be achieved. It should be noted that in many cases the tab on the TSCR simply deflected allowing the TSCR and steering wheel to rotate as a unit with no breakage of the insertions pins and horn contacts.

**Question 2:**

(2) Five warranty claims are for VINs not listed in the production table: 981706, 013341, 186185, 019425, and 971276. This suggests that the warranty search was based on all vehicles, not just TSCR equipped vehicles. Any comments?

**Response:**

The warranty claims search was based upon the three different TSCR part numbers used. It was not based only upon the VINs that appear in the production table. The five additional warranty claims are most likely due to incorrect data entry by the servicing dealer of either the VIN or the part number.

**Question 3:**

(3) What is the purpose of the approx 1/8" hole that is drilled and tapped into the steering assembly housing at approx the 3:00 o'clock position (right side of steering wheel) machined at approximately 45 degrees from the axis of the steering column? What is the length of the machine screw that it installed into that hole? What is the thickness of the part that is mounted to the column at that point? Does the installed machine screw protrude beyond the casting? If so, how far does it extend beyond the end of the hole? Has the length of screw, thickness of parts, depth of hole changed since 1997?

**Response:**

The purpose of the hole in question and the adjacent hole in the same plane is to mount the wiper/washer control switch on the right-hand side of the steering column. In some instances,

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this is also used to mount an engine retarder switch. The length of the mounting screws vary from 10 mm to 12 mm depending on the number of switches (wiper/washer and/or engine retarder).

The steering column casting is a purchased part and VTNA has no detailed information as to the thickness of the casting in the area of the mounting of the switches. The sample part sent to you earlier can be measured to determine if there could be any screw protusion.

**Question 4:**

(4) VTNA response to Question 15 indicates that no inspection notes or reports were prepared for any TSCR parts returned from the field. It seems that some inspection and associated documentation must have been created to support the engineering changes made to the TSCR over time (e.g. the change notice allegedly states "problem with the plugs on the ring breaking, caused by fatigue..." There must been some basis (photographs, reports, etc) for this opinion.

**Answer:**

Interviews have again been conducted of available persons who would have been involved in the analysis. They have no recollection of parts being received from dealers or others demonstrating the failures. The evaluation and testing discussed earlier was driven almost exclusively by the number of warranty claims that had been received. The failure rate was not acceptable.

**Question 5:**

(5) Just to confirm VTNA statement, there are no lawsuits (e g for crashes or the commercial dispute with Pro Transportation)?

**Answer:**

No lawsuits have been filed that the TSCR or related components caused an accident.

**Question 6:**

(6) Enclosed Field Report 24688 does not appear to have any bearing on the subject of this investigation. Was the correct report enclosed?

**Answer:**

Field report 24688 was erroneously attached to the submittal.

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**Question 7:**

(7) Warranty claim narratives for reports 992707and 200526 are truncated. The final portion of the narrative says either "cont" or "more." Can VTNA furnish the missing text.

**Answer:**

992707 "STEERING COLUMN CLIPPED COVER UNDER STEERING WHEEL BROKEN, WE R/R IT & SCREW AT STEERING WHEEL. P.S. ALLOW US MORE TIME TO VERIFY ALL THINGS AS PER DRIVER COMPLAINT"

200526 "SIGNALS WAS SMASHED & WAS HOLDING THE SPRING LOADED TERMINALS OFF OF THE CONNECTIONS, REPLACED RING & RECHECKED, FOUND NO FURTHER PROBLEMS."

**Question 8:**

(8) Production Volumes with revised build dates. We discussed that it woud be appropriate to build two Access files: (1) one file listing vehicles built with the TSCR WITH the complementary turn signal switch –- approx 16,202 vehicles and (2) one file listing vehicles built with the TSCR WITHOUT the complementary turn signal switch. Both files would list the part number of the TSCR associated with each VIN listed.

**Answer:**

It should be noted Volvo Trucks North America has used three different part numbers for TSCRs and six different part numbers for turn signals with the self-cancelling feature. Some trucks called for a TSCR eventhough they may not have called for a self-cancelling turn signal.

Refer to the enclosed CD-ROM. As for vehicles without self-cancelling turn signals, see Microsoft Access table "TSCR_Only.mdb" and for vehicles with self-cancelling turn signals, see table "VIN_TSCR_w_SCTS-Switch.mdb".

If you have any questions, please feel free to contact me.

Yours truly,

Heino W. Scharf
Director, Product Assurance

**EA04-016**
**Appendix D**
**Sheet 1 of 4**

**Review of Closed Investigations EA02-021 and PE01-041**

(1) EA02-021 - EA02-021 addressed the integrity of the front suspension U-bolts installed in 1996-2003 VTNA VN Series vehicles. ODI inspected three crash vehicles as a part of EA02-021. In each of these vehicle crashes, the VTNA tractor departed the road and crashed or rolled in a manner that suggested that the driver might have lost steering control. The investigative findings of EA02-021 led ODI to conclude that the front suspension U-bolts had not been factors in causing these crashes. Although this investigation eliminated front suspension U-bolt integrity as a causal factor, the investigation did not pursue the reasons that these vehicles had left the roadway. In the context on the current investigation, PE04-014, ODI compared the crash vehicle VINs with the list of VINs equipped with a TSCR to determine whether these three vehicles had been equipped with a TSCR. This analysis determined that none of the crash vehicles was equipped with a TSCR. Therefore, ODI has concluded that there is no evident linkage between the EA02-021 incidents and this current investigation (PE04-014).

(2) PE01-041 - PE01-041 addressed "Alleged Steering Gearbox or [Steering Shaft] U-Joint Failures" pertaining to 1998-2000 model year VTNA VN-410, 610, 660, 770, and STD (Day Cab) tractor trailers. The PE01-041 closing report provides the following potentially relevant information:

(A) Based on reports from 19 vehicle owners whose complaints were listed in an Owner-Operator Independent Drivers Association (OOIDA) report, "2 operators reported that plastic turn signal parts inside the steering wheel hub caused the steering wheel to bind."

(B) VTNA provided 60 owner/operator complaints of which "4 [were] reports of binding [that] resulted from broken plastic turn signal parts becoming lodged in the steering wheel hub."

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(C) VTNA also provided 951 warranty claims of which "5 claims did involve broken plastic parts inside the steering wheel hub."

(D) VTNA provided a summary chart that summarized measurements of steering wheel torque required to "cancel/overpower the flasher," "to break reset," and "to break brushes." VTNA obtained this summary data by testing four "sample" TSCRs.

ODI requested VTNA to provide information regarding the procedure for this test. On March 25, 2004, VTNA responded, "VTNA does not have a written procedure for this test."

VTNA originally provided the data to ODI in PE01-041 in bar chart format; ODI has re-stated the values reported in PE01-041 in the table below.

"Flasher reset measurements" furnished by VTNA for PE01-014
Values reported in N-m (Neuton-meters)
(Values in parenthesis indicate N-m values stated in lb-ft)

| Event | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Cancel/ overpower flasher | 1.29 (.95 lb-ft) | 1.55 (1.15 lb-ft) | No data provided | No data provided |
| To break reset | 11.26 (8.30 lb-ft) | 10.76 (7.93 lb-ft) | 15.02 (11.07 lb-ft) | 12.40 (9.14 lb-ft) |
| To break brushes | 3.00 (2.21 lb-ft) | 3.23 (2.38 lb-ft) | 3.34 (2.46 lb-ft) | No data provided |

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In the current investigation, PE04-014, ODI re-considered the above data and measured a sample VTNA steering wheel and found that the steering wheel is approximately 18 inches in diameter. ODI calculated the steering wheel force (one hand) required to achieve that maximum steering wheel torque reported in the above table (i.e., 11.07 lbs-ft required to "break reset" for Event # 3). ODI calculated that a driver would need to apply 14.8 lbs of force to an 18" diameter steering wheel to achieve the steering wheel force to overcome the "most demanding" condition summarized in the above table.

In PE01-041, VTNA advised ODI that the Motor Carrier Maintenance Council Recommended Practice RP623, in its Definition and Common Phrases Section, defines "hard steering" as occurring when the steering wheel effort exceeds 18-22 pounds. In PE01-041, ODI was persuaded by the above data that "binding forces caused by the fractured parts of the turn signal canceling ring (which at worst are still only about ½ of the force allowed by RP623) do not constitute a safety risk." ODI notes that the above calculated estimation of 14.8 lbs of steering wheel force is in the regime of 18 – 33% below the 18-22 lbs of force required to qualify as "hard steering" as defined by RP623.

ODI questions whether the steering torque values measured by the above-referenced test and incorporated in PE01-041are relevant to the current investigation because the "flasher reset measurements" appear to measure the steering wheel torque needed to overcome prescribed conditions defined as, "cancel/overpower the flasher," "to break reset," and "to break brushes." (ODI has requested VNTA to provide a more specific description of the testing conducted. VTNA advised ODI that no written procedure for the test exists.)

ODI was concerned that the test does not address the potentially higher steering wheel forces that might be unexpectedly encountered if a portion of the broken, bent, deformed, or displaced TSRC were to wedge itself in the steering wheel system and restrain the driver's ability to steer. The steering wheel effort required to overcome a broken, bent, deformed, or displaced piece of a TSCR that has wedged into the steering wheel mechanism could be significantly larger that the steering effort required to "cancel/overpower the flasher," "to break reset," and "to break brushes."

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To address these concerns, ODI conducted simulations to evaluate whether there appeared to be any conditions or circumstance under which a "broken, bent, deformed, or displaced piece of a TSCR" might be able to fall or wedge in some portion of the steering wheel and shaft mechanism and obstruct, interfere, and/or possibly "jam" the steering wheel significantly and thereby cause a significant and unexpected increase in steering effort. See Paragraph 5 "ODI Simulations," in Section 6, "ODI Investigation" of the reports for a description and summary of the findings of these simulations.

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**Appendix E**
**Sheet 1 of 7**

Summary of Visit, Federal Express East, Brook Park, Ohio –

13813 Brook Park Road, Brook Park, Ohio
Inspection Conducted September 8, 2004; Summary prepared on September 9, 2004

Fed Ex operates 5 1998 VTNA tractors at Brook Park depot. According to VTNA records, these tractors were originally equipped with TSCR part number 1607363 (original TSCR installed by VTNA in certain 1997 – 2000 MY tractors). The tractors operated by VTNA did not incorporate a turn signal switch that had a self-canceling feature.

Four tractors were available for inspection. Following is a summary of the inspection results. Each of the four TSCRs inspected exhibited at least one broken retention leg.

| Fleet Unit No. | VIN | Number of Legs Broken Off TSCR | Number of Broken Legs Found | Position where Broken leg(s) found | Photograph |
|---|---|---|---|---|---|
| 3046 | 4VA7BAP FXWN XXXXXX | 4 | 2 of 4 | Pieces found upright in strg wheel bore |  |

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| | | | | | |
|---|---|---|---|---|---|
| 3022 | 4VA7BAP F7WN XXXXXX | 4 | 0 of 4 | No pieces of broken legs were found |  |
| 3078 | 4VA7BAP F1WN XXXXXX | 5 | 5 of 5 | One piece found between outer horn contact ring and TSCR "trapped" at "unused" cutout in TSCR by leg "barb" |  |
| 3058 | 4VA7BAP F6WN XXXXXX | 4 | 3 of 4 | One piece found between steering shaft and TSCR |  |

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Reference Information

| Fleet Unit No. | VIN | Build Date | Mileage on Sept 8, 2004 |
|---|---|---|---|
| 3046 | 4VA7BAPFXWNXXXXXX | Oct 30, 1997 | 719,591 |
| 3022 | 4VA7BAPF7WNXXXXXX | Oct 24, 1997 | 802,465 (*) |
| 3078 | 4VA7BAPF1WNXXXXXX | Nov 19, 1997 | 700,324 |
| 3058 | 4VA7BAPF6WNXXXXXX | Nov 4, 1997 | 802,822 (**) |

(*) 15,657 on currently installed odometer. (**) 18,478 on currently installed odometer.

**********

Summary of Visit – Federal Express East, 13301 Grover Court, Chester, Virginia Inspection Conducted September 11, 2004; Summary prepared on September 14-15, 2004

Fed Ex operates eleven 1999 VTNA tractors from the Chester depot. According to VTNA records, these tractors were originally equipped with TSCR part number 1607363 (original-design TSCR installed by VTNA in certain 1997 – 2000 MY tractors). The tractors operated by FedEx did not incorporate a turn signal switch that had a self-canceling feature.

Of the original eleven candidates, nine tractors were available for inspection on September 15, 2004 (tractors # 3401 and # 3402 had been moved to another FedEx terminal).

ODI did not find a TSCR installed in the steering wheel of tractor # 4226 when it was inspected. Subsequent research of FedEx service records indicated that this tractor was in a crash on April 4, 2002, and the steering gear and steering wheel were replaced at that time. Evidently, the TSCR was not installed in the replacement steering wheel. (There would have been no need to install the TSCR at the time of servicing since the turn signal switch is not equipped with the self canceling feature and therefore, the TSCR does not provide any function.)

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Following is a summary of the inspection results listed in the order that the vehicles were inspected.

| Fleet Unit No. | VIN | Number of Legs Broken Off TSCR | Number of Broken Legs Found | Position where Broken leg(s) found | Photograph / Comments |
|---|---|---|---|---|---|
| 3881 | 4VA7BAPF7XNXXXXX | 0 | 0 | ---- | One leg found in position but cracked |
| 3888 | 4VA7BAPFXXNXXXXXX | 1 | 1 | Found in Bore in Strg Wheel Cavity | No photo taken |
| 4226 | 4VA7BAOF1XNXXXXX | ---- | ---- | ---- | No TSCR in steering wheel; likely removed during prior servicing. See above note. |
| 3825 | 4VA7BAPFXXNXXXXXX | 3 (1 cracked) | 3 (See foot-note) | Found in Bores in Strg Wheel Cavity |  |

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| | | | | | |
|---|---|---|---|---|---|
| 3315 | 4VA7BAPF6XNXXXXX | 4 | 1 | Found on tractor floor (most likely dislodged when the steering wheel nut was loosened) |    Above photo indicates that the embedded plastic piece (unknown source) had been trapped and abraded between TSCR and horn contact ring |

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| | | | | | |
|---|---|---|---|---|---|
| 3887 | 4VA7BAPF8 XNXXXXX X | 2 (*) | 2 (*) | ---- | (*) ODI heard "crack" when removing TSCR indicating that at least one leg broke during the removal process |
| 3882 | 4VA7BAPF9 XNXXXXX X | 4 | 4 | Found in Bores in Strg Wheel Cavity |  |
| 4008 | 4VA7BAPF5 XNXXXXX X | 3 | 3 | Found in Bore in Strg Wheel Cavity |  One leg in position, but cracked |
| 3893 | 4VA7BAPF3 XNXXXXX X | None | All Intact (*) | ---- | (*) ODI heard "crack" when removing TSCR indicating that at least one leg broke during the removal process |

Footnote: A small plastic piece from an unknown source was found in steering wheel cavity of Unit 3825

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**Appendix E**
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Reference Information

| Fleet Unit No. | VIN | Build Date | Mileage on Sept 11, 2004 |
|---|---|---|---|
| 3881 | 4VA7BAPF7XNXXXXXX | 10/19/98 | 872,378 |
| 3888 | 4VA7BAPFXXNXXXXXX | 10/20/98 | 237,749 * |
| 4226 | 4VA7BAOF1XNXXXXXX | 02/02/99 | 507,226 |
| 3825 | 4VA7BAPFXXNXXXXXX | 10/09/98 | 764,022 |
| 3315 | 4VA7BAPF6XNXXXXXX | 04/30/98 | 845,874 |
| 3887 | 4VA7BAPF8XNXXXXXX | 10/20/98 | 820,333 |
| 3882 | 4VA7BAPF9XNXXXXXX | 10/20/98 | 855,609 |
| 4008 | 4VA7BAPF5XNXXXXXX | 11/10/98 | 883,148 |
| 3893 | 4VA7BAPF3XNXXXXXX | 10/22/98 | 650,446 ** |

(*) 15,673 miles indicated on currently installed odometer. (**) 92,540 miles indicated on currently installed odometer.