

ENGINEERING ANALYSIS CLOSING SUMMARY

SUBJECT VEHICLES: 2008-2013 Toyota Highlander

EA No.: 18-006

Date Opened: 16 Nov 2018

Date Closed: 02 April 2024

BASIS:

Three Vehicle Owners Questionnaires (VOQ) reporting detachment of the upper steering column from the vehicle structure prompted the Office of Defects Investigation (ODI) to open a Preliminary Evaluation (PE18-005). Information collected from Toyota in the PE identified additional field incidents and specific information about the subject system's engineering. On November 16, 2018, ODI upgraded PE18-005 to an Engineering Analysis (EA18-006) to conduct a more detailed analysis of the involved vehicles, components, and incidents. Both investigations focused on detachments of the upper steering column from the vehicle structure.

SUBJECT SYSTEM:

The steering column assembly is mounted on the instrument panel reinforcement by the shear capsules secured to the breakaway bracket. Basic illustrations of the system are shown in Figure 1 and Figure 2. The subject system is part of the energy management system that reduces occupant injury risk in frontal collisions by shearing away.

ODI conducted a peer review of vehicles within model years 2006-2015. This included patent searches and vehicle inspections. Fourteen vehicles from eight manufacturers were inspected. Eight vehicles utilized shear capsules as the steering wheel loading countermeasure. The other six vehicles utilized other methods (tear plates, shear-head / break-off bolts, pyrotechnic release pins and deforming material inside sliding tube). A patent search showed a combination of shear type designs and alternative designs (deformation, tear) during the timeframe 2000-2015. The search was not comprehensive and was meant to establish technology available at the time.

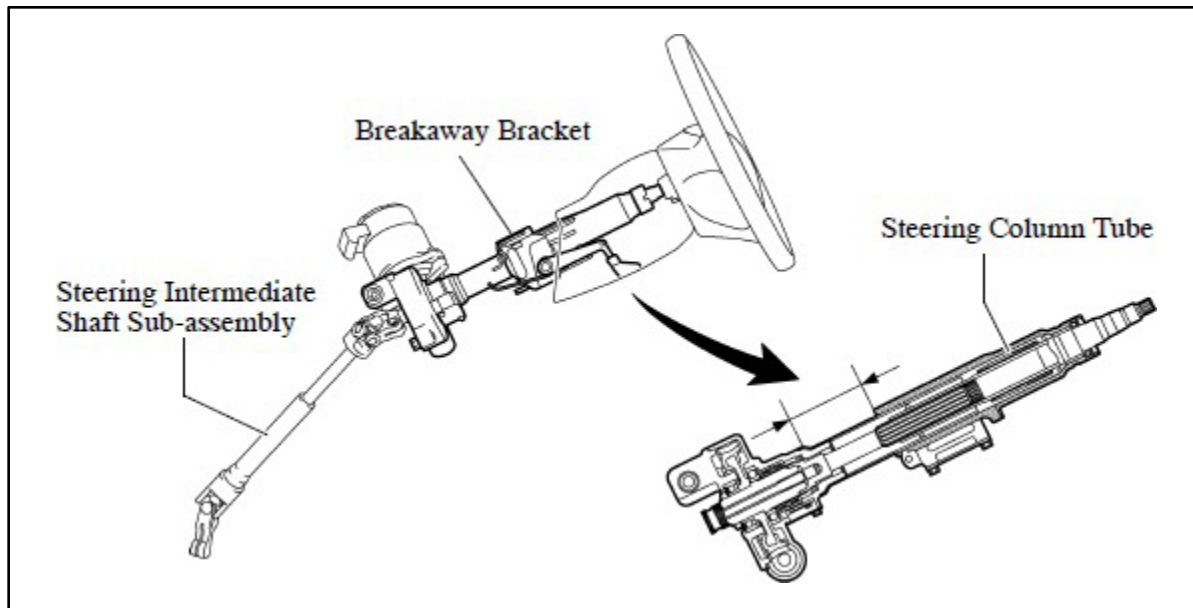


Figure 1. Steering Column Assembly

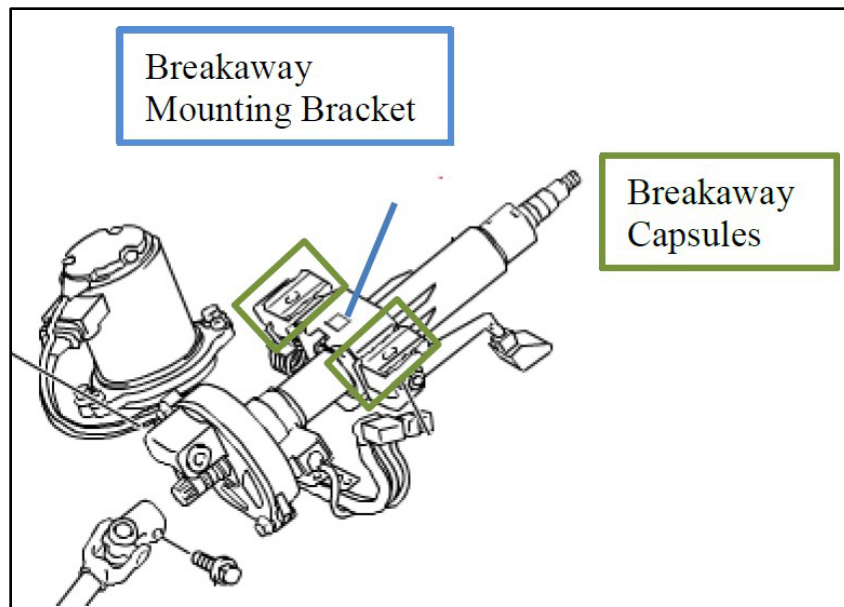


Figure 2. Breakaway Bracket and Breakaway [Shear] Capsules

SUBJECT SYSTEM CHANGES:

MY2008 and MY2009 vehicles use a three-pin design with MY2010-2014 vehicles transitioning to a four-pin design.

MANUFACTURER ASSESSMENT:

Toyota stated that it has not identified any defect of the breakaway capsules or the subject component and has also not identified any trend or pattern in the isolated cases it identified that relate or may relate to the alleged defect. Toyota additionally stated that reports of steering column separation are rare (three cases) with one injury and no credibly alleged crashes.

INVESTIGATION ANALYSIS:

During PE18-005, ODI analyzed incidents reported through Vehicle Owner Questionnaires (VOQ) and examined the field data, warranty data, and relevant technical information submitted by Toyota in response to the information request letter for PE18-005. ODI also confirmed that the steering column in the subject vehicles is equipped with shear capsules that are designed to collapse/shear during certain types of vehicle collisions. This design feature strives to reduce occupant injury severity resulting from vehicle collisions. Two different shear capsule designs were used in the subject vehicles. MY2008-2009 used a three retaining pin design, MY2010-2013 used a four retaining pin design using the same dimensions and could be used interchangeably during steering column repairs. ODI learned that there is no visual method of detection to determine whether the capsules in a vehicle are broken. If the driver operates the tilt/telescoping feature after the breakaway capsules have sheared, the steering column may drop out of position and/or may separate entirely from the dashboard if the driver pulls the steering column toward them.

After upgrading to an EA, ODI identified 14 incidents involving complete separation of the upper steering column from the lower steering column, 6 of which occurred while driving, and 1 of which involved a minor crash. There have been 16 additional incidents reported where the steering column has dropped from the dashboard mounting brackets. Four (4) of these incidents occurred while driving.

Toyota issued a collision repair information bulletin in November 2018 [CRIB 192] to instruct technicians to inspect the steering column and shear capsules when making repairs after any collision.

ODI continued its examination of potential field incidents during the EA and commissioned testing of the subject components by NHTSA's Vehicle Research and Test Center (VRTC).

The number of known occurrences is shown in Table 1. In the total number of occurrences, 21 vehicles reported collision damage prior to the separation event.

Table 1. Reported Failures (Toyota and ODI reports combined)

	Model Year	Production	Reported Occurrences	Drop	Separations
3-Pin	2008	162,015	25	24	11
	2009	68,011	2	2	1
4-Pin	2010	92,335	1	1	0
	2011	85,141	0	0	0
	2012	132,152	7	4	1
	2013	168,413	8	6	3
	Total	708,067	42	37	16

VRTC obtained a field shear capsule from an automotive used parts facility and sectioned it to verify the condition of the injection molded pins (Figure 3). Both the right and left shear capsules were sectioned,

with the right capsule shown below in Figure 4. A visual inspection with a microscope found no voids, foreign material, discoloration, or other anomalies with the retaining pin material.



Figure 3. Right Shear Capsule



Figure 4. Sectioned Right Shear Capsule

VRTC mailed a questionnaire to owners of MY 2008 through MY 2013 Toyota Highlanders in Ohio to identify possible candidates for steering column component testing. A total of 1,689 questionnaires were mailed with 466 responses received. Results of the mail survey indicated no verifiable instances and no test candidates were selected from the response pool.

VRTC conducted testing to gather data on the force needed to cause the shear capsule to break. A 2010 Toyota Highlander, previously used in NHTSA testing, was built into a test buck/fixture (Figure 5). The driver's seat was removed and replaced with a reinforced bracket. A pneumatic cylinder and load cell were attached between the bracket and steering wheel. The telescoping upper column was set to mid position and locked, the cylinder was activated, force and pressure information were collected. Five upper steering column assemblies were purchased through an automotive used parts facility. The VINs were provided for each steering column assembly and the donor vehicles listed no prior frontal collisions on a vehicle history report. Five steering column assemblies were tested in the fixture: four containing 3-pin shear capsules and one containing 4-pin shear capsules. The test fixture was inspected for damage after each test. After the fifth test, deformation of the floor pan was observed. Data from that test was found to be compromised by the deformation. Testing on this fixture was suspended.



Figure 5. Vehicle Test Fixture

Further component-level testing of the shear capsules was performed on an MTS Multiple Actuator Test System. The MTS test setup was configured to match Toyota's pre-production component testing (Figure 6). Shear capsules removed from steering column assemblies were purchased through an automotive used parts facility. Ten 3-pin capsules and seven 4-pin capsules were tested (see Tables 2 and 3). The average separation force for the 3-pin shear capsule was 404.1 lbf (1.79 kN), approximately 20 % higher result than the preproduction testing conducted by Toyota in 2008. Thus, testing demonstrated that there was no degradation in strength of the shear capsules assessed and the preproduction testing conducted by Toyota.



Figure 6. VRTC Test Fixture

Table 2. MTS testing of Toyota Highlander 3-pin shear capsule

VIN	Year	Test #	Force	
			lbf	kN
JTEDS41A782XXXXXX	2008	MTS-010	353	1.57
JTEES43A392XXXXXX	2009	MTS-150	654	2.91
JTEDA41A792XXXXXX	2009	MTS-200	388	1.73
JTEES41A582XXXXXX	2008	MTS-210	469	2.09
JTEES41A082XXXXXX	2008	MTS-220	369	1.64
JTEES43A392XXXXXX	2008	MTS-230	406	1.80
JTEDS41A192XXXXXX	2009	MTS-240	257	1.14
JTEES41A482XXXXXX	2008	MTS-250	403	1.79
JTEES41A982XXXXXX	2008	MTS-260	359	1.60
JTEDS43AX82XXXXXX	2008	MTS-270	383	1.70

Table 3. MTS testing of Toyota Highlander 4-pin shear capsule

VIN	Year	Test #	Force	
			lbf	kN
5TDBK3EH9ASXXXXXX	2010	MTS-020	633	2.82
JTEBK3EH1A2XXXXXX	2010	MTS-100	743	3.30
5TDBK3EHXDSXXXXXX	2013	MTS-110	450	2.00
5TDBK3EH0DSXXXXXX	2013	MTS-120	713	3.17
5TDZA3EH0CSXXXXXX	2012	MTS-130	744	3.31
5TDBK3EH9CSXXXXXX	2012	MTS-140	692	3.08
5TDJK3EH3ASXXXXXX	2010	MTS-160	893	3.97

CONCLUSION:

This investigation is closed given that:

- Vehicle crash history appears to contribute to the known failures;
- Separation tends to occur when operating the tilt and/or telescoping function after the two shear capsules have separated;

- Testing shows that field-used shear capsule performance did not degrade over ten years of exposure; and
- The overall low rate of occurrence since the updated manufacturer notification to repair documentation (with the most recent non-crash history bracket failure occurring in 2021).

The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists. The agency reserves right to take further action if warranted by the circumstances.