UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
BETHESDA, MD 20814

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DATE: November 22, 2016

TO: The Commission
Todd A. Stevenson, Secretary

THROUGH: Mary T. Boyle, General Counsel
Patricia H. Adkins, Executive Director

FROM: Patricia M. Pollitzer, Assistant General Counsel
Barbara E. Little, Attorney, OGC

SUBJECT: Recreational Off-Highway Vehicles (ROVs)—Termination of Rulemaking
BALLOT VOTE DUE - Wednesday, November 30, 2016

Staff is forwarding to the Commission a briefing package recommending that the Commission terminate the rulemaking associated with ROVs that began with the publication of an advance notice of proposed rulemaking in the *Federal Register* in October 2009 (74 Fed. Reg. 55495 (Oct. 28, 2009)).

Please indicate your vote on the following options:

I. Terminate the rulemaking associated with ROVs, and direct staff to draft and publish a *Federal Register* notice announcing the Commission's termination of the ROV rulemaking.

______________________________ ______________
(Signature) (Date)

II. Do not terminate the rulemaking associated with ROVs.

______________________________ ______________
(Signature) (Date)

III. Take other action. (Please specify.)

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(Signature) (Date)

Attachment: Briefing Package: Evaluation of Voluntary Standards for Recreational Off-Highway Vehicles (ROVs)

EVALUATION OF VOLUNTARY STANDARDS FOR RECREATIONAL OFF-HIGHWAY VEHICLES (ROVs)

November 2016

For Further Information Contact:

Caroleene Paul
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Directorate for Engineering Sciences
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EXECUTIVE SUMMARY

Background: Recreational off-highway vehicles (ROVs) are motorized vehicles that combine off-road capability with utility and recreational use. In response to CPSC staff concerns with reports of ROV-related fatalities and injuries, two different organizations developed separate voluntary standards for ROVs. The Recreational Off-Highway Vehicle Association (ROHVA) developed ANSI/ROHVA 1 *American National Standard for Recreational Off-Highway Vehicles* for recreation-oriented ROVs and the Outdoor Power Equipment Institute (OPEI) developed ANSI/OPEI B71.9 *American National Standard for Multipurpose Off-Highway Utility Vehicles* for utility-oriented ROVs.

Work on ANSI/ROHVA 1 started in 2008, and completed with the publication of ANSI/ROHVA 1-2010. The standard was immediately opened for revision, and a revised standard, ANSI/ROHVA 1-2011, was published in July 2011. The standard was revised again in 2014, and most recently in 2016.

Work on ANSI/OPEI B71.9 was started in 2008, and completed with the publication of ANSI/OPEI B71.9-2012 in March 2012. The standard was most recently revised in 2016.

This package summarizes the analyses performed by CPSC staff to evaluate the lateral stability, vehicle handling, and occupant protection performance requirements for ROVs in ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016.

Evaluation of Voluntary Standards: As of August 26, 2016, CPSC staff is aware of 942 reported ROV-related incidents with at least one death or injury that occurred on or after January 1, 2003; there were 665 reported fatalities and 843 reported injuries related to these incidents. In 2012, CPSC staff conducted a multidisciplinary review of 428 ROV-related incidents resulting in at least one injury or death that occurred between January 1, 2003 and December 31, 2011, and reported to CPSC staff on or before December 31, 2011.[1] Of the 428 incidents, 291 (68 percent) involved lateral rollover of the vehicle. A total of 826 victims were involved in the 428 reported incidents, including 231 fatalities and 388 injuries. One hundred-fifty of the 231 fatalities (65 percent) and 67 of the 75 severely injured victims (89 percent) were involved in a lateral rollover of the ROV. Of the 610 fatally and non-fatally injured victims who were on an ROV at the time of the incidents, 433 (71 percent) were either partially or fully ejected from the ROV, and 269 (62 percent) of the 433 victims were struck by a part of the vehicle. Seat belt use or non-use is known for 374 of the injured or killed victims; of these, 282 (75 percent) victims were not wearing a seat belt at the time of the incident. Of the 225 fatally injured victims who were in or on the ROV at the time of the incident, 194 (86 percent) were ejected partially or fully from the vehicle. Seat belt use is known for 155 of the 194 ejected victims; of these, 141 (91 percent) were not wearing a seat belt.

Based on the incident data, CPSC staff believes that, to reduce deaths and injuries associated with ROVs, ROV rollover and occupant ejection is a dominant hazard that needs to be addressed. Improving the lateral rollover resistance and vehicle steering characteristics of ROVs

[1] Received as of December 31, 2011. All incident analysis is based on reported information.

is a strategy for reducing the occurrence of ROV rollover events. Increasing occupant protection performance of ROVs is a strategy to protect ROV users when rollover events occur.

In 2016, ROHVA and OPEI revised their respective voluntary standards to:

- Modify lateral stability requirements, by revising the tilt table requirements and introducing a new requirement for a hang tag, which displays the maximum tilt table performance of the vehicle;
- Introduce new vehicle handling requirements that prohibit oversteer, which can lead to divergent instability;
- Revise occupant protection requirements by requiring a seat belt reminder that limits maximum vehicle speed to 15 mph if the driver's seat belt is not buckled; and
- Revise occupant protection requirements by requiring more robust seat belt performance and side retention barrier performance.

CPSC staff evaluated the lateral stability, vehicle handling, and occupant protection performance requirements for ROVs in ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016. Staff believes that the revised voluntary standards are likely to reduce the occurrence of ROV rollovers, by increasing lateral stability and prohibiting divergent instability; and staff also believes that the voluntary standards are likely to reduce the occurrence of occupant ejection during rollover events, by increasing seat belt use and improving side retention. For these reasons, staff believes the current voluntary standards will adequately address the risk of ROV rollover and occupant ejection.

Furthermore, staff estimates that a large percentage of ROVs will comply with ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 because ROHVA and OPEI members are the North American ROV manufacturers who participated in the development of the standard, and these member companies sell more than 90 percent of the ROVs in the United States. Several of the voluntary standards provisions do not become effective until 2018;therefore, compliance rates cannot be stated definitively. However, staff believes ROV voluntary standards compliance is moving in the right direction, and staff expects that, in light of ROHVA and OPEI active participation in the standards development process, over 90 percent of ROVs are likely to comply with the voluntary standards around the time of the effective dates of the two standards.

Conclusion: Staff believes that the revised voluntary standards are likely to (1) reduce the occurrence of ROV rollovers by increasing lateral stability and prohibiting divergent instability; and (2) reduce the occurrence of occupant ejection during rollover events by increasing seat belt use and improving side retention. Moreover, staff believes ROV compliance with the voluntary standards is trending toward increased compliance, a positive development that staff expects will ultimately lead to an adequate reduction in the risk of ROV rollover and occupant ejection once the standards become effective. For these reasons, staff recommends that the Commission terminate rulemaking on ROVs.

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Memorandum November 15, 2016

TO: The Commission
Todd Stevenson, Secretary

THROUGH: Mary T. Boyle , General Counsel
Patricia H. Adkins, Executive Director

FROM: George A. Borlase, Assistant Executive Director
Office of Hazard Identification and Reduction
Caroleene Paul, Project Manager
Directorate for Engineering Sciences

SUBJECT: Evaluation of Voluntary Standards for Recreational Off-Highway Vehicles (ROVs)

I. INTRODUCTION

Recreational off-highway vehicles (ROVs) are motorized vehicles that have four or more tires, non-straddle seating, automotive-type controls for steering, throttle, and braking, and a maximum vehicle speed greater than 30 miles per hour (mph).[2] ROVs combine off-road capability with utility and recreational use, and ROVs have become very popular in the United States. In response to CPSC staff concerns with reports of ROV-related fatalities and injuries, two different organizations developed separate voluntary standards for ROVs. The Recreational Off-Highway Vehicle Association (ROHVA) developed ANSI/ROHVA 1 *American National Standard for Recreational Off-Highway Vehicles* for recreation-oriented ROVs and the Outdoor Power Equipment Institute (OPEI) developed ANSI/OPEI B71.9 *American National Standard for Multipurpose Off-Highway Utility Vehicles* for utility-oriented ROVs.

Work on ANSI/ROHVA 1 started in 2008, and completed with the publication of ANSI/ROHVA 1-2010. The standard was immediately opened for revision, and a revised standard, ANSI/ROHVA 1-2011, was published in July 2011. The standard was revised again in 2014, and most recently in 2016.

Work on ANSI/OPEI B71.9 was started in 2008, and completed with the publication of ANSI/OPEI B71.9-2012 in March 2012. The standard was most recently revised in 2016.

Both voluntary standards address design, configuration, and performance aspects of ROVs, including requirements for accelerator and brake controls; service and parking brake/parking mechanism performance; lateral and pitch stability; lighting; tires; handholds; occupant protection; labels; and owner's manuals. The latest revisions of the voluntary standards specifically include additional requirements for lateral stability, vehicle handling aimed at

[2] Definition from ANSI/ROHVA 1 *American National Standard for Recreational Off-Highway Vehicles.*

prohibiting oversteer that can lead to divergent instability, and occupant protection aimed at increasing seat belt use and occupant retention during a rollover.

CPSC staff participated in the canvass process used to develop consensus for ANSI/ROHVA 1 and ANSI/OPEI B71.9. From June 2009 to the present, CPSC staff actively engaged with ROHVA and OPEI through actions that include:

- sending correspondence to ROHVA and OPEI with comments on voluntary standard ballots that outlined CPSC staff's concerns that the voluntary standard requirements for lateral stability were too low, that requirements for vehicle handling were lacking, and that requirements for occupant protection were not robust;
- participating in public meetings with ROHVA and OPEI to discuss development of the voluntary standard and to discuss static and dynamic tests performed by contractors on behalf of CPSC staff;
- sharing all CPSC contractor reports with test results of static and dynamic tests performed on ROVs by making all reports available on the CPSC website; and
- conducting dynamic tests proposed by ROHVA/OPEI members and providing the test results to the voluntary standards organizations in open comment letters to pre-canvass and canvass draft proposals.

On October 23, 2014, CPSC staff engineers met with ROV manufacturers' engineers to discuss the technical issues related to the areas of concern identified by CPSC staff: lateral stability, vehicle handling, and occupant protection.[3] Since then, CPSC staff worked with ROV manufacturers to conduct testing and evaluation of ROVs and to develop performance requirements to address staff's concerns. In February 2016, staff received canvass drafts from ROHVA and OPEI with proposed requirements that addressed most of staff's suggestions for improved lateral stability, vehicle handling, and occupant protection.

Staff reviewed both canvass drafts and determined that the requirements for rollover resistance, vehicle handling, and occupant protection addressed most of staff's concerns with ROV rollovers and occupant protection, as communicated to ROHVA and OPEI during development of the standards. On March 11, 2016, CPSC staff sent comment letters to ROHVA and OPEI, stating that staff supported the proposed changes to the voluntary standards and believed the aggregate effect of improved vehicle stability, handling, and occupant protection would reduce injuries and deaths associated with ROV rollovers.[4]

[3] Meeting log dated October 23, 2014. Retrieved from: http://www.cpsc.gov//Global/Newsroom/FOIA/Meeting%20Logs/2015/CPSCMeetingwithRecreationalOffHighwayVehicleAssociationROHVA.pdf.

[4] Letter from Caroleene Paul (CPSC) to Thomas Yager (ROHVA), dated March 11, 2016. Retrieved from: https://www.cpsc.gov/s3fs-public/pdfs/foia_CPSClettertoROHVAcommentrecirculationballotdraftANSIROHVA1201X.pdf and letter from Caroleene Paul (CPSC) to Greg Knott (OPEI), dated March 11, 2016. Retrieved from: https://www.cpsc.gov/s3fs-public/pdfs/foia_CPSCletterOPEIcommentsecondcanvassdraftANSIOPEIB7192016.pdf.

On April 18, 2016, ANSI approved ANSI/ROHVA 1-2016, and the revised standard was published in May 2016. On May 13, 2016, ANSI approved ANSI/OPEI B71.9-2016, and the revised standard was published August 2, 2016.

This package summarizes the analyses performed by CPSC staff to evaluate the requirements in the voluntary standards for ROVs, and whether compliance with those requirements is likely to adequately reduce the risk of injury identified with ROVs.

II. EVALUATION OF VOLUNTARY STANDARDS

In this section staff assesses the hazards associated with ROVs that present an unreasonable risk of injury and whether the voluntary standard requirements adequately reduce the risk of injury associated with those hazards.

A. Hazards associated with ROVs

As of August 26, 2016, CPSC staff is aware of 942 reported ROV-related incidents with at least one death or injury that occurred on or after January 1, 2003. There were 665 reported fatalities and 843 reported injuries related to these incidents. In 2012, CPSC staff conducted a multidisciplinary review of 428 ROV-related incidents resulting in at least one injury or death that occurred between January 1, 2003 and December 31, 2011, and that were reported to CPSC staff on or before December 31, 2011.[5,6] To assess the voluntary standards, staff considered the hazard patterns staff had previously identified in its review of ROV-related incidents.

<u>ROV Rollover</u>

Of the 428 reported ROV-related incidents, 291 (68 percent) involved rollover of the vehicle, with more than half of the incidents occurring while the vehicle was in a turn (52 percent). Of the 224 fatal incidents, 147 (66 percent) involved rollover of the vehicle, and 56 of these 147 incidents (38 percent) occurred on flat terrain.

Based on the incident data, CPSC staff believes that, to reduce deaths and injuries associated with ROVs, ROV rollover is a dominant hazard that needs to be addressed. Improving the lateral rollover resistance and vehicle steering characteristics of ROVs is a strategy for reducing the occurrence of ROV rollover events. ROVs that exhibit higher rollover resistance are more stable than ROVs with lower rollover resistance. Therefore, increasing rollover resistance of ROVs may reduce the occurrence of rollovers. In addition, ROVs that exhibit stable vehicle handling characteristics are less likely to roll over due to loss of control. Therefore, requirements that prohibit unstable vehicle handling may reduce the occurrence of rollovers.

[5] Received as of December 31, 2011. All incident analysis is based on reported information.
[6] Garland, S. (2012). Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs). Safety Standards for Recreational Off-Highway Vehicles. Tab D. Retrieved from: http://www.cpsc.gov/Global/Newsroom/FOIA/CommissionBriefingPackages/2014/SafetyStandardforRecreationalOff-HighwayVehicles-ProposedRule.pdf.

Occupant Ejection and Seat Belt Use

Of the 428 reported ROV-related incidents, 817 victims were reported to be in or on the ROV at the time of the incident; and 610 victims (75 percent) were known to have been injured or killed. Seatbelt use is known for 477 of the 817 victims; of these, 348 victims (73 percent) were not wearing a seatbelt at the time of the incident. Of the 610 fatal and nonfatal victims who were in or on the ROV at the time of the incident, 433 victims (71 percent) were ejected partially or fully from the ROV; and 269 (62 percent) of these victims were struck by a part of the vehicle, such as the roll cage or side of the ROV, after ejection. Seat belt use is also known for 374 of the 610 victims; of these, 282 victims (75 percent) were not wearing a seat belt.

Of the 225 fatal victims who were in or on the ROV at the time of the incident, 194 victims (86 percent) were ejected partially or fully from the vehicle, and 146 victims (75 percent) were struck by a part of the vehicle after ejection. Seat belt use is known for 155 of the 194 ejected victims; of these, 141 victims (91 percent) were not wearing a seat belt.

Based on the incident data, CPSC staff believes that, to reduce deaths and injuries associated with ROVs, occupant ejection is a dominant hazard that needs to be addressed. Improving the occupant protection performance of ROVs is a strategy for reducing the severity of injuries to occupants when ROVs do roll over, and increasing seat belt use is the primary method to improve occupant protection. Additional factors, such as seat belt technology and passive side restraints, maximize the occupant protection provided by seat belts. Occupants who remain within the confines of the rollover protective structure (ROPS), often called a roll cage, of an ROV in a rollover event are less likely to be crushed by the vehicle. Therefore, increasing occupant protection will reduce the injury severity of ROV occupants when rollover events occur.

B. Addressing Rollover - Lateral Stability

ANSI/OPEI B71.9-2016 and ANSI/ROHVA 1-2016 rely on a tilt table test to measure the tilt table angle of the ROV to define performance requirements for static lateral stability. The tilt table angle is measured by placing the ROV on a rigid platform and tilting the platform (see Figure 1). The angle of the platform relative to the horizontal is the tilt table angle. The vehicle's rollover resistance is measured at the angle when all up-hill wheels of the vehicle lift off the platform.

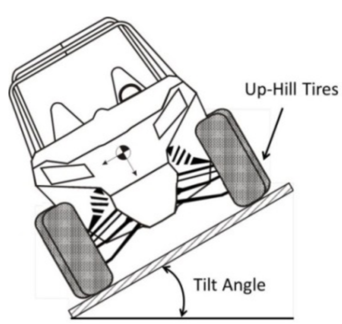


Figure 1. Tilt table angle

Voluntary Standard Requirement

Tilt Table Stability. **ANSI/OPEI B71.9-2016 Section 8.6 and ANSI/ROHVA 1-2016 Section 8.1** specify a procedure to place a vehicle, with test weights to simulate two different test load configurations, on a tilt platform and laterally tilt the platform until the vehicle achieves the minimum tilt angle requirements. The tilt table test platform is specified with a 1-inch-high rail, also known as a trip rail, parallel to the tilt axis to engage the side of the downhill tires to prevent the vehicle from sliding during the tilt table test.

A vehicle configured with two occupants must reach a minimum of 33 degrees before lateral tip over, to meet the tilt table requirements. A vehicle configured with the maximum number of occupants and full cargo load must reach a minimum of 24 degrees before lateral tip over, to meet the tilt table requirements.

Tilt Table Hang Tag. **ANSI/OPEI B71.9-2016 Section 5.18 and ANSI/ROHVA 1-2016 Section 4.17** require that vehicles be equipped with a hang tag that provides consumers with the tilt table angle at two-wheel lift for that vehicle when loaded in the operator-plus-passenger configuration. "Two-wheel lift" is defined as the "condition in which the uphill tires are no longer in contact with the test surface."

CPSC Staff's Evaluation

CPSC staff does not believe a requirement for a minimum tilt table angle of 33 degrees, by itself, will increase the rollover resistance of ROVs. Staff contracted SEA Limited (SEA) to measure the tilt table angle, with a 1-inch trip rail, at two-wheel lift, of several model year 2014 and 2015 ROVs.[7] Test results show that the tilt table angles at two-wheel lift ranged from 36.0 to 40.7 degrees. Based on these tests, staff believes that a requirement for a tilt table angle of 33 degrees is very low and easy to achieve; and therefore, this tilt table angle should be considered a baseline minimum requirement.

However, staff believes that combining a minimum tilt table angle requirement with a hang tag requirement that displays the vehicle's maximum tilt table angle at two-wheel lift will increase the rollover resistance of ROVs by providing an incentive for manufacturers to increase the rollover resistance of ROVs. NHTSA developed the New Car Assessment Program (NCAP) star-rating system in 1978, to provide consumers with information on the crashworthiness of passenger vehicles.[8] In 2001, NHTSA began including rollover resistance information in its NCAP because it believed that consumer information on the rollover risk of passenger cars would influence consumers to purchase vehicles with a lower rollover risk and inspire manufacturers to produce vehicles with a lower rollover risk.[9,10] A subsequent study of rollover

[7] Heydinger, G. (2015) Tilt Table Measurements on Twenty-Two Recreational Off-Highway Vehicles. Retrieved from http://www.cpsc.gov//Global/Research-and-Statistics/Injury-Statistics/Sports-and-Recreation/ATVs/SEAReportTiltTableResults22ROVsSept2015.pdf.
[8] Hershman, L. (2001). The U.S. New Car Assessment Program (NCAP): Past, Present and Future. Paper Number 390. Retrieved from: http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv17/proceed/00245.pdf.
[9] Walz, M. C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809 868. Retrieved from: http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html.

resistance trends in automobiles, as defined by a vehicle's static stability factor (SSF), found that the rollover resistance increased for all vehicles after 2001, particularly SUVs, which tended to have the worst SSF values in the earlier years.**Error! Bookmark not defined.** CPSC staff believes that a similar increase in rollover resistance may be achieved in ROVs with the voluntary standard requirement for a hang tag that displays the rollover resistance of each ROV. With a metric of the ROV's rollover resistance made available to the public, consumers may demand vehicles with higher rollover resistance and manufacturers may have a competitive incentive to increase the rollover resistance of their vehicles. ROVs that exhibit higher rollover resistance are more stable than ROVs with lower rollover resistance. Therefore, increasing rollover resistance of ROVs may reduce the occurrence of rollovers.

C. Addressing Rollover - Vehicle Handling

Vehicle handling refers to the steering characteristic of the ROV where the vehicle may exhibit understeer, neutral steer, and oversteer. Too much oversteer can lead to divergent instability, a condition marked by a sudden increase in yaw rate, or spinning motion of the ROV that is unstable and uncontrollable. ANSI/OPEI B71.9-2016 and ANSI/ROHVA 1-2016 rely on a constant steer angle test to define a vehicle handling performance requirement that prohibits oversteer that can lead to divergent instability.

A vehicle's steering characteristic can be measured in a constant-steer angle test. The constant-steer angle test is performed by driving the vehicle on a specified circular path at a very low speed to measure the steering wheel angle required to maintain the vehicle's center of gravity (CG) over the path at the specified radius. Once the necessary steering wheel angle has been determined, the steering wheel is fixed and the vehicle speed is slowly increased from zero up to the speed where the vehicle experiences two-wheel lift, spins out, or is unable to increase speed due to engine limitation. The vehicle's angular velocity about its vertical axis (see Figure 2), measured in degrees per second, can be measured during the test and analyzed to evaluate the vehicle's steering characteristic. ROHVA and OPEI call this test the yaw rate test.

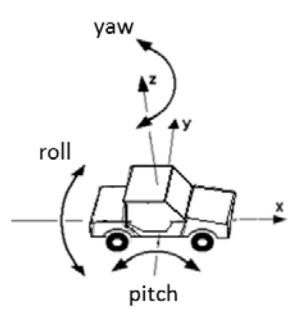


Figure 2. Vehicle axes.

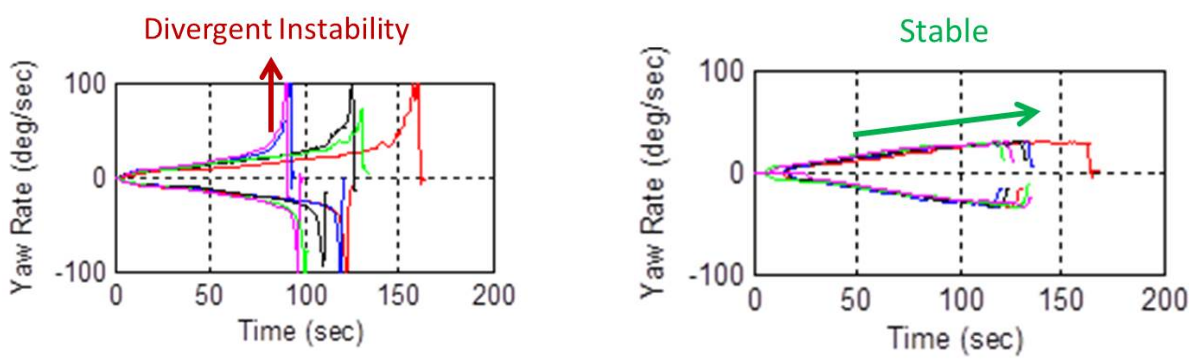
In June 2015, ROHVA and OPEI proposed using a yaw rate test with a 50-foot radius to measure the yaw rate gain of ROVs as a characteristic to evaluate the vehicle's handling. The proposed vehicle handling requirement compared the yaw rate gain at the beginning of the test to the yaw rate gain at the end of the test and computed a ratio of the slopes of the yaw rate plots. ROHVA

[10] 65 FR 34988 (June 1, 2000).

and OPEI proposed that vehicles with a higher ratio value represent vehicles that exhibit divergent instability.

CPSC staff contracted SEA to conduct yaw rate tests of several ROVs at the Ackermann[11] angle for a 50-foot radius turn.[12] Test results showed that the yaw rate test is capable of detecting divergent oversteer as a function of yaw rate increase, as shown in Figure 3. The slope of the yaw rate gain increase approaches infinity in a vehicle exhibiting divergent instability, compared to linear yaw rate gain in a stable vehicle.

CPSC staff provided yaw rate data on nine vehicles to ROHVA and OPEI in a letter dated July 7, 2015. In the letter, staff agreed that a performance requirement based on the constant-steer angle test can be developed to ensure that ROVs do not exhibit divergent instability, if the appropriate criteria are used to determine the pass/fail performance. Based on the preliminary test results, staff suggested modifications to the performance criteria to ensure that ROVs do not exhibit divergent instability. At a public meeting on July 8, 2015, CPSC staff and OPEI members discussed the yaw rate test data, and staff expressed concern that vehicles that exhibit divergent instability would pass the proposed yaw rate test performance requirements.[13]



Yaw Rate of a Vehicle Exhibiting Divergent Instabiliy

Yaw Rate of a Vehicle Exhibiting Divergent Instabiliy

Figure 3. Examples of divergent and stable yaw rate gain during constant-steer angle test.
Source: Letter from Caroleene Paul to Greg Knott dated July 7, 2015. Retrieved from: http://www.cpsc.gov//Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/070715CPSClettertoOPEIcommenttoprecanvassdraft%20ANSIOPEIB719201X.pdf.

Staff continued to conduct yaw rate tests and review and analyze the test data. CPSC staff provided baseline yaw rate data on 11 vehicles to ROHVA and OPEI in a letter dated August 21,

[11] Ackermann angle is the angle of the road-wheels required to turn the vehicle at any given turn radius when there are no steering deviations due to understeer or oversteer. To calculate the angle, use the equation: Ackermann Angle = arctangent (wheelbase/turn radius)
[12] Heydinger, G. et al. (2016). Yaw Rate Ratio Measurements of Recreational Off-Highway Vehicles Results from Constant Steer Angle Tests Conducted on 11 Vehicles. Retrieved from: http://www.cpsc.gov//Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/SEAFinalReporttoCPSC-YawRateRatioMeasurementsofROVsJune2016wcoverletter(6bcleared).pdf.
[13] Meeting log dated July 8, 2015. Retrieved at: http://www.cpsc.gov//Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/070715CPSClettertoOPEIcommenttoprecanvassdraft%20ANSIOPEIB719201X.pdf

2015, in which staff suggested more accurate methods to measure yaw rate slopes to ensure that divergent characteristics were captured.[14] ROHVA and OPEI agreed with staff's suggestions and worked with SEA to refine the test protocols for vehicle handling testing.

Voluntary Standard Requirement

Vehicle Handling. **ANSI/OPEI B71.9-2016 Section 8.8 and ANSI/ROHVA 1-2016 Section 10** each specify a method to: (1) measure and evaluate the extent of oversteer behavior in a vehicle; (2) identify vehicles that could exhibit divergent instability; and (3) establish performance criteria that limit the amount of permissible oversteer. The vehicle handling requirements for ROVs use constant steer tests to compute a metric generally referred to as "yaw rate ratio," and the performance requirement is based on the values of the yaw rate ratios.

The test procedure describes a tire break-in procedure, followed by procedures to establish the steer angle required to drive the test vehicle on a 50-foot radius at a slow speed. Once the steer angle is established and the test vehicle's steering wheel is locked at this angle, the driver slowly increases the speed of the vehicle until one of the following occurs:

- The vehicle no longer accelerates, or
- The vehicle achieves two-wheel lift.[15]

The test procedure requires five test runs in the right/clockwise and five test runs in the left/counter-clockwise directions, with instrumentation recording the vehicle speed, yaw rate, and steer angle. Plots of the vehicle's yaw rate versus speed are used to determine the pass/fail criteria for vehicle handling. The specified computations calculate the slope of the yaw rate from 0.1 g to 0.2 g[16] (a condition when the vehicle is moving slowly around the circle) and the slope of the yaw rate from 0.4 g to 0.5 g (a condition when the vehicle is moving around the circle at higher speed). The ratio R is defined as the slope of the yaw rate plot at the end of the test, divided by the slope of the yaw rate plot at the start of the test, as follows:

$$R = \frac{(Y2/V2)}{(Y1/V1)}$$

Where:

Y2/V2 = Linear slope of yaw velocity versus time plot divided by linear slope of vehicle speed versus time plot in region between 0.4 and 0.5 g of lateral acceleration

Y1/V1 = Linear slope of yaw velocity versus time plot divided by linear slope of vehicle speed versus time plot in region between 0.1 and 0.2 g of lateral acceleration

The R values for the five test runs in the right/clockwise direction are averaged for the Final Slope Ratio Right and the R values for the five test runs in the left/counter-clockwise are averaged for the Final Slope Ratio Left. The performance requirements state that no test shall

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[14] Letter from Caroleene Paul, CPSC, to Greg Knott, OPEI, dated August 21, 2015. Retrieved from: http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/082115CPSClettertoOPEIsuggestedlinefitmethodandlatestyawratedata.pdf.

[15] Two-wheel lift is defined in dynamic tests as the condition in which all tires on the inside of the turn lift above the test service at least 2 inches.

[16] Acceleration is expressed as a multiple of free-fall gravity (g), which is equal to 9.81 m/s^2 (32.2 ft/s^2).

result in two-wheel lift, and the Final Slope Ratio Right and Final Slope Ratio Left cannot exceed a value of 4.5.

<u>CPSC Staff's Evaluation</u>

CPSC staff believes a vehicle handling requirement that prohibits divergent instability will reduce the occurrence of ROV rollovers caused by loss of control of an ROV that has become unstable. Rollover occurs when a side force (caused by lateral acceleration) rotates the vehicle 90 degrees or more about its roll axis. When the rollover occurs due to the forces generated by impact of a vehicle that is in a slide with an object, such as a curb or a berm, the rollover is called a tripped rollover. When the rollover occurs due only to forces generated during a turn, the rollover is called an untripped rollover. CPSC staff believes that the sudden increase in lateral acceleration and yaw rate that is associated with divergent instability can cause a sudden untripped rollover of a vehicle or can cause a vehicle to slide and experience tripped rollover.[4,17] Industry manufacturers have also stated that divergent instability is hazardous because the vehicle is uncontrollable once the condition is reached, and a spinning vehicle poses a tripped rollover hazard.[18]

After ROHVA and OPEI proposed the yaw rate test to measure vehicle handling in a pre-canvass draft of proposed revisions to ANSI/ROHVA 1 and ANSI/OPEI B71.9,[19] CPSC staff contracted SEA to conduct yaw rate tests of several ROVs on a 50-foot radius circle.

SEA's test results were published in June 2016, in the report titled, "Yaw Rate Ratio Measurements of Recreational Off-Highway Vehicles."[20] This report will be referred to as the SEA Yaw Rate report. SEA conducted baseline yaw rate ratio tests of 11 vehicles, and conducted repeat measurements on five of the 11 vehicles.

SEA used the following test procedure:

1. Follow a 50 ft. radius circle at a speed less than 10 mph until the mean steer angle required to maintain the circular path is established (this is referred to as "initial steer" in this report). Once the initial steer angle has been determined, bring the vehicle to a stop.
2. The SEA Automated Steering Controller (ASC) was then used to steer the steering wheel to the initial steer angle and hold it there for the duration of the test.
3. The vehicle was then steadily accelerated at a rate not to exceed 1mph/second. For all of the tests listed as "Baseline" tests, the total time for one test run was generally between

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[17] Letter from Caroleene Paul, CPSC, to Tom Yager, ROHVA, dated May 23, 2014. Retrieved at: http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/052314signedCommentLettertoROHVACanvassDraft03032014.pdf.
[18] Meeting log dated March, 10 2015. Retrieved from: http://www.cpsc.gov//Global/Newsroom/FOIA/Meeting%20Logs/2015/Meeting_Log_Polaris-dynamic_stability.pdf
[19] OPEI comment to NPR. Retrieved at regulations.gov link.
[20] Heydinger, G. et al. (2016) Yaw Rate Ratio Measurements of Recreational Off-Highway Vehicles. Retrieved from: http://www.cpsc.gov//Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/SEAFinalReporttoCPSC-YawRateRatioMeasurementsofROVsJune2016wcoverletter(6bcleared).pdf.

90 to 120 seconds. For all other tests (listed as 30-60 sec), the total time for one test run was generally between 30 to 60 seconds.

4. The tests were ended when a lateral acceleration of at least 0.5 g was achieved.
5. Items 2-4 were repeated until at least five runs in the first steer direction were completed.
6. Item 1 was repeat in the opposite steer direction, and then Items 2-4 were repeated until at least five runs in the opposite steer direction were completed.

SEA used the following steps to compute the yaw rate ratios contained in the report:

1. For each test run, to determine the data regions for analysis, the yaw rate and speed channels were filtered using a low-pass Butterworth filter with a cut-off frequency of 2 Hz.[21] Then the estimated lateral acceleration in units of "g" was computed using the following equation[22]:

$$Estimated\ A_y = \frac{\pi}{180} \times \frac{Yaw\ Rate \times Speed}{32.2}$$

where *Yaw Rate* is in deg/sec and *Speed* is in ft/sec.

2. The estimated lateral acceleration, *Estimated Ay*, was used to determine the start and stop points for the following regions:

   a. The Initial Region is from 0.1 g to 0.2 g.
   b. The Final Region is from 0.4 g to 0.5 g.

3. For each test run, in both initial and final regions, linear slopes of unfiltered yaw rate versus data index and linear slopes of unfiltered speed versus data index were computed.[23] The slopes can be classified as:

   a. Y1 = linear slope of yaw rate versus index plot for Initial Region
   b. Y2 = linear slope of yaw rate versus index plot for Final Region
   c. Y3 = linear slope of the vertical speed versus index plot for Initial Region
   d. Y4 = linear slope of the vertical speed versus index plot for Final Region

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[21] Original data processing protocols submitted to CPSC by industry representatives suggested the use of a 2 Hz low- pass filter, but the current protocols in the OPEI and ROHVA voluntary standards call for a 1 Hz low-pass filter. Refer to Appendix G of http://www.cpsc.gov//Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/SEAFinalReporttoCPSC-YawRateRatioMeasurementsofROVsJune2016wcoverletter(6bcleared).pdf for a discussion of the merits of using 1 Hz filtering.

[22] The region selection method used for the data presented in this report takes the first instance of Estimated A_y crossing 0.1 g to the first instance of it crossing 0.2 g, and the first instance of Estimated A_y crossing 0.4 g to the first instance of it crossing 0.5 g. Current protocols in the OPEI and ROHVA voluntary standards call for using continuous regions of Estimated A_y between 0.4 g and 0.5 g.

[23] Current protocols in the OPEI and ROHVA voluntary standards call for computing slopes versus time. Given the form of the final computation for Yaw Rate Ratio, computing the slopes versus time or versus data index result in the same answer for Yaw Rate Ratio.

4. The Yaw Rate Ratio (R) for each run was then computed using the following equation:

$$R = \frac{(Y2/V2)}{(Y1/V1)}$$

5. Steps 1 through 4 were repeated for all ten test runs.

6. The following final slope ratios were then computed:
   a. Right Turn Yaw Rate Divergence Ratio = Average of the 5 right turn test runs[24]
   b. Left Turn Yaw Rate Divergence Ratio = Average of the 5 left turn test runs[20]
   c. Average Yaw Rate Divergence Ratio = Average of the Right Turn and Left Turn Yaw Rate Divergence Ratios

Test results of the yaw rate ratios for the vehicles tested by SEA are shown below in Figure 4:

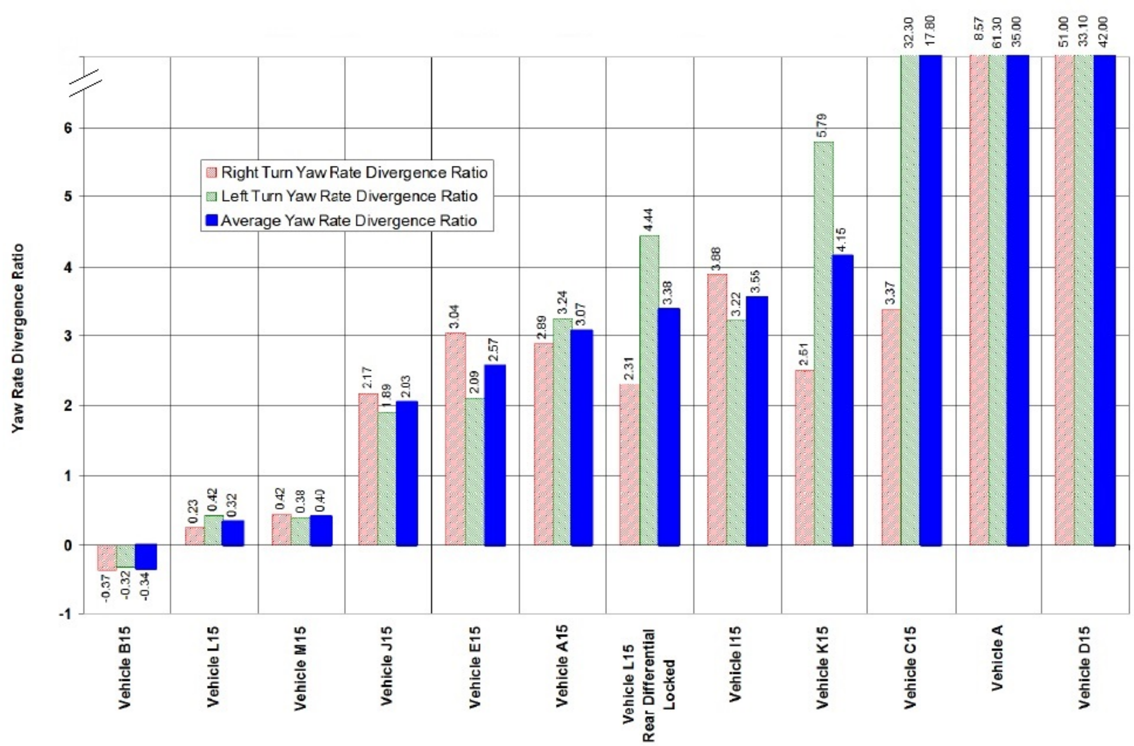

Figure 4. Yaw Rate Ratio Test Results from Baseline Tests on 11 Vehicles

Results of the baseline tests and repeat testing of several vehicles (Vehicles A15, B15, E15, I15, and J15) indicate that vehicles that exhibit greater understeer have less variation in their individual yaw rate ratios, and therefore, have more repeatable final yaw rate ratio results.

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[24] Current protocols in the OPEI and ROHVA voluntary standards compute Final Slope Ratio Right and Final Slope Ratio Left by averaging the absolute values of the slope ratios for the five runs in each direction.

Conversely, vehicles that exhibit greater oversteer have more variation in their individual slope ratios, and therefore, have less repeatable final yaw rate ratio results. As shown in Figure 4 and the data from Appendix A of the SEA Yaw Rate report, vehicles that exhibit the most understeer (Vehicles B15, L15, M15, and J15) have the least variance in individual yaw rate slopes and the lowest yaw rate ratios. Conversely, vehicles that exhibit severe transition to oversteer (Vehicles I15, K15, C15, A, and D15), have high variance in individual yaw rate slopes and the highest yaw rate ratios.[25]

CPSC staff provided baseline yaw rate data on 11 vehicles to ROHVA and OPEI in a letter dated August 21, 2015, in which staff suggested more accurate methods to measure yaw rate slopes to ensure that divergent characteristics were captured.[26] ROHVA and OPEI agreed with staff's suggestions, and worked with SEA to refine the test protocols for vehicle handling testing. In June 2016, ROHVA and OPEI published ANSI/ROHVA 1-2016 and ANSI/OPEI B71.0-2016. Both standards have identical vehicle handling requirements. However, there are minor differences in the test protocols between the finalized voluntary standard requirements and the protocols used by SEA to produce the data in the Yaw Rate report and the data that were provided to ROHVA and OPEI during development of the voluntary standards. The vehicle handling test protocols in ANSI/ROHVA 1-2016 and ANSI/B71.9-2016 differ from the SEA protocol in the following areas:

- Test duration
- Filtering of yaw rate and speed data
- Selection method for slope in Final Region (0.4 g to 0.5 g) of yaw rate test
- Center of gravity (CG) height of the test load representing the weight of two occupants.

Appendix G of the SEA Yaw Rate report compares differences between the protocols in the published voluntary standards and the SEA Yaw Rate report. The analysis in Appendix G shows that the voluntary standards' protocols are more stringent or not significantly different than the protocols used by SEA. An analysis of the differences follows:

Test Duration – 60 seconds versus 90 to 120 seconds

ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 specify that yaw rate tests should be conducted over a period that does not exceed one minute. SEA conducted baseline tests of the 11 vehicles with tests that were conducted over a period of 90 to 120 seconds, but also conducted multiple follow-up tests over a period of 30 to 60 seconds. SEA compared test data on tests that were conducted between 30 to 60 seconds with tests that were conducted between 90 to 120

[25] Severity of vehicle transition to oversteer is found in Appendix C of report titled *Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Results from Tests on Thirteen 2014-2015 Model Year Vehicles*, retrieved from: http://www.cpsc.gov//Global/Research-and-Statistics/Injury-Statistics/Sports-and-Recreation/ATVs/SEAreportVehicleCharacteristicsMeasurementsROVResultsTests%20Thirteen20142015ModelYearVehicles.pdf.

[26] Letter from Caroleene Paul, CPSC, to Greg Knott, OPEI, dated August 21, 2015. Retrieved from: http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/082115CPSClettertoOPEIsuggestedlinefitmethodandlatestyawratedata.pdf.

seconds and found no discernable difference in the test results. Therefore, CPSC staff believes that the voluntary standard protocol for a test duration that does not exceed one minute is adequate because the yaw rate test results will not be substantially different from the testing performed by SEA.

Processing data using 2 Hz versus1 Hz low-pass filter

ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 specify using a cut-off frequency of 1 Hz to filter all data channels. SEA used a low-pass Butterworth filter with a cut-off frequency of 2 Hz to filter the yaw rate and speed channels to determine the data regions for analysis of the yaw rate slopes. SEA reprocessed the baseline test data using a cut-off frequency of 1 Hz and found the yaw rate ratio results were somewhat greater using a 1 Hz filter. Therefore, CPSC staff believes that the voluntary standard protocol to process the data channels with a 1 Hz cut-off frequency is adequate because the R value is likely to be higher, thus resulting in a more stringent requirement.

Selection method for slope calculation in Final Region of 0.4 g to 0.5 g lateral acceleration

The estimated ground plane lateral acceleration, Ay, is used to determine the start and stop points for the regions over which the yaw rate and speed slopes are calculated.[27] ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 specify selecting: "the first continuous zone of data where the value increases from 0.4 g to 0.5 g [indicated by the black line in the figure below] as opposed to any momentary value that crosses the 0.4 g or 0.5 g line." For some test runs in the Final Region, the data cross back-and-forth over the 0.4 g value and over the 0.5 g value, as shown in Figure 5 below. SEA used the first instance of data crossing 0.4 g of lateral acceleration and the first instance of data crossing 0.5 g of lateral acceleration to calculate the slope over the Final Region. SEA reprocessed the baseline test data using the continuous method for region selection and found that the yaw rate ratio results were somewhat higher using the continuous region selection method. Therefore, CPSC staff believes the voluntary standard protocol of using the continuous zone method to identify the Final region when calculating yaw rate slope is adequate because the R value is likely to be higher, thus resulting in a more stringent requirement.

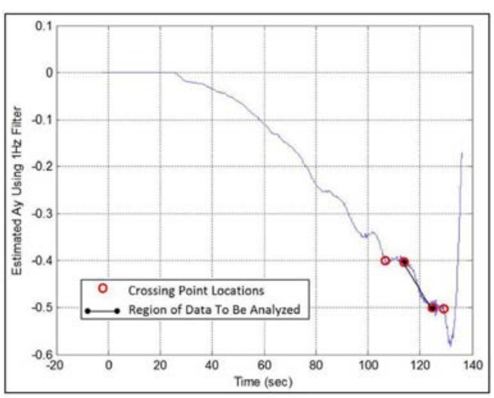


Figure 5. Example of continuous zone versus first-cross data selection.

[27] Initial Region is 0.1 g to 0.2 g and Final Region is 0.4 g to 0.5 g

CG height of test load at 10 inches versus 6 inches

ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 specify that the instrumented ROV with outriggers and test operator shall simulate an ROV loaded with two 215-lb occupants whose CG height is 6 inches above the seating surface. SEA's test vehicle configuration simulated an ROV loaded with two 215-lb occupants whose seated CG height is 10 inches above a seating surface. SEA has historically used a CG height of 10 inches, based on literature containing measurements of CG heights for seated humans.[28]

Due to funding restrictions, SEA was not able to retest the vehicles with weights adjusted to simulate two occupants with CG heights that are 6 inches above the seating surface. However, SEA does not believe the small differences in CG height (between 6 inches or 10 inches) of the test load are significant because the yaw rate is measured about the vertical axis of the vehicle's CG, as shown in Figure 6. CG height generally affects roll and pitch because it determines load transfer from side to side and between front and rear. In a steady-state condition like the yaw rate test, there is no load transfer about the yaw/vertical axis; therefore, there is little effect from measuring the yaw rate at different points along the yaw axis.

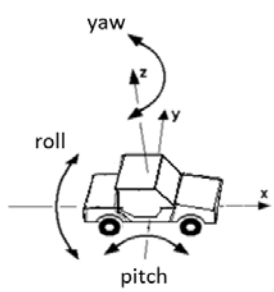


Figure 6. Vehicle axes.

In addition, CPSC staff notes that the effective vehicle CG location is comprised of the outrigger, instrumentation, operator, and ballast; and the voluntary standards specify distribution of all the weights to match operator and passenger locations as closely as possible. Therefore, there will be variations in vehicle CG height, due to variations in outriggers, test operators, and test instrumentation.

For these reasons, CPSC staff believes the voluntary standard specification for the test vehicle to simulate an ROV loaded with two 215-lb occupants, whose CG height is 6 inches above the seating surface, is adequate because the yaw rate test results will not be substantially different from the testing performed by SEA.

<u>Conclusion</u>

Results of the yaw rate ratios for the vehicles tested by SEA using ROHVA and OPEI protocol (with exception of CG height being 10 inches instead of 6 inches) are shown in Figure 7 below:

[28] Schultz, R. et al. (1996) Whole Body Center of Gravity and Moments of Inertia. Retrieved from: http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ada328863.

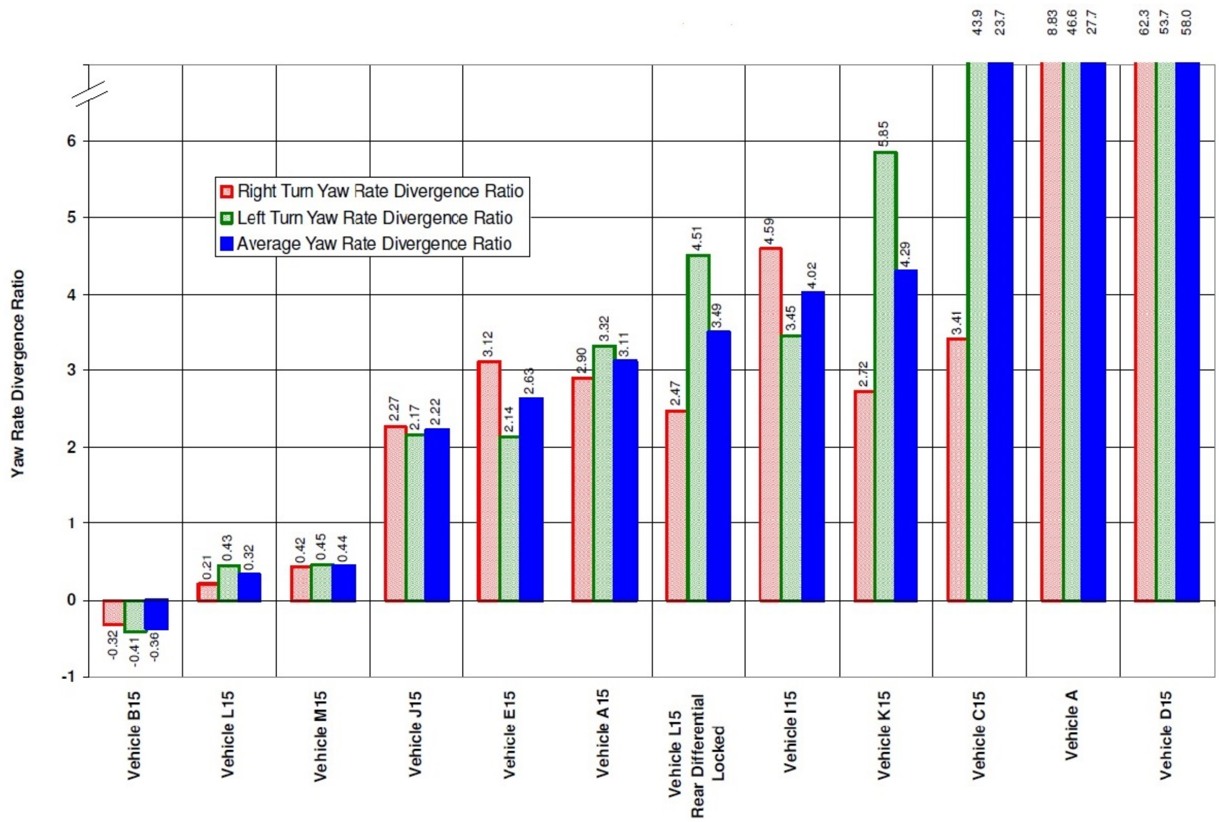


Figure 7. Yaw Rate Ratio Test Results from Baseline Tests on 11 Vehicles (Using OPEI and ROHVA test protocols).

Test results shown in Figure 7 show that lower R values are associated with vehicles that exhibit understeer and higher R values are associated with vehicles that exhibit severe oversteer that exhibit divergent instability. The vehicle handling requirement of an R value below 4.5 in the Left and Right directions eliminates vehicles that CPSC staff has identified as vehicles that exhibit divergent instability. In addition, at a meeting on October 5, 2015, ROHVA representatives stated that manufacturers will design vehicles with an R value in the 3.5 range to meet a requirement of 4.5, due to reproducibility concerns and manufacturing margins and tolerances.[29] Therefore, based on preliminary test results of model year 2014 and 2015 ROVs, staff believes that the vehicle handling requirements in ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9 -2016 will prohibit divergent instability in ROVs, and thus, reduce injuries and deaths associated with ROV rollover events.

D. Addressing Occupant Ejection - Occupant Protection

ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 include similar provisions to address occupant retention during a rollover event.

[29] Meeting Log dated October 5, 2015. Retrieved from: http://www.cpsc.gov//Global/Newsroom/FOIA/Meeting%20Logs/2016/ROHVAPublicVoluntaryStandardsMeeting.pdf.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2016 Section 12.1 Seat Belts** and **ANSI/OPEI B71.9-2016 Section 5.1.3.1 Seat Belts** specify that ROVs shall be equipped with a three-point seat belt that shall include an Emergency Locking Retractor (ELR) with a locking angle determined by the manufacturer based on the vehicle's intended use.

CPSC Staff's Evaluation

CPSC staff believes that a requirement for seat belts with an ELR will reduce deaths and injuries associated with ROVs by maximizing occupant retention during a rollover event. CPSC staff contracted SEA to conduct dynamic occupant protection performance tests on several model year 2009-2011 ROVs and follow-up tests on several model year 2014-2015 ROVs.[30,31] SEA designed and built a vehicle roll simulator to measure and analyze occupant response during quarter-turn roll events, and SEA validated the roll simulator with measurements taken from autonomous roll over tests.[32] On July 7, 2015, CPSC staff sent a letter to OPEI and ROHVA, providing results from roll simulation tests showing that a seat belt without ELR technology did not lock during a 90-degree roll, and consequently, failed to restrain an occupant during a simulated rollover event.

SEA roll simulator testing showed that ROVs without a solid shoulder retention barrier and a tilt-sensing ELR could result in the occupant coming out of the protective zone defined by the vehicle's ROPS during a 45-degree roll over. Vehicle H, shown in Figure 8, does not have a passive shoulder barrier; nor was it equipped with a tilt-sensing ELR. CPSC staff's testing of the seat belt on Vehicle H verified that the seat belt does not lock throughout a 90-degree tilt range. SEA roll simulator testing of Vehicle H shows the seat-belted occupant's head coming out of the protective zone of the ROPS during a simulated roll over (see Figure 9).

[30] Morr, D.R. (2012). Test and Evaluation of Recreational Off-Highway Vehicles (ROVs) Dynamic Occupant Protection Performance Tests. Retrieved from: http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ROVOccupantProtectionPerformanceTests.pdf.
[31] Zagorski, S. and Sidhu, A. (2016). Dynamic Occupant Protection Performance Tests for Recreational Off-Highway Vehicles (ROVs). Retrieved from: http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/SEADynamicOccupantProtection.pdf.
[32] See Section III.B.4. of Briefing Package Notice of Proposed Rulemaking (NPR) for Recreational Off-Highway Vehicles (ROVs) in *Safety Standard for Recreational Off-Highway Vehicles (ROVs)*. Retrieved from: http://www.cpsc.gov/Global/Newsroom/FOIA/CommissionBriefingPackages/2014/SafetyStandardforRecreationalOff-HighwayVehicles-ProposedRule.pdf.

Figure 31: Vehicle H Side View

Figure 8. **Vehicle H with shoulder and lap belt, without shoulder barrier.**

Figure 32: Occupant H at 45° Roll

Figure 9. Occupant coming out of the ROPS zone during a simulated rollover. Seatbelt does not have a tilt-sensing ELR.

SEA roll simulator testing showed that vehicles with tilt-sensing ELR performed better than vehicles without ELRs. Vehicle C, shown in Figure 10, does not have a passive shoulder barrier, but was equipped with a tilt-sensing ELR. CPSC staff's testing of Vehicle C verified that the seatbelt locks at a tilt angle of approximately 53 degrees. By cross-referencing the lateral acceleration seen in the SEA sled tests, with the acceleration associated with the locking angle of the inertial seat belt, the inertial spool lock was determined to have engaged at approximately 10 degrees of vehicle roll. Figure 11 shows the occupant remaining in the protective zone of the ROPS during a simulated roll over. CPSC staff believes that the combination of the belt routing and the tilt sensing ELR contributed to limited occupant excursion.

Figure 23: Vehicle C Side View

Figure 10. Vehicle C with shoulder and lap belt, without shoulder barrier.

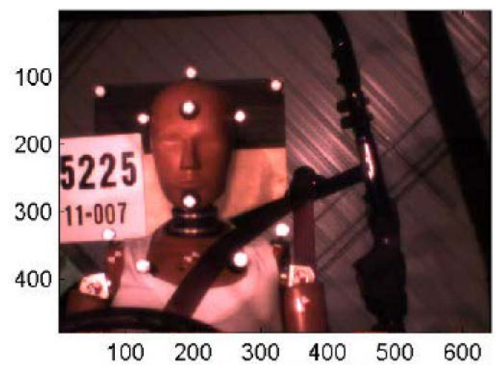


Figure 24: Occupant C at 45° Roll

Figure 11. Occupant remaining in the ROPS zone during a simulated rollover. Seat belt has a tilt-sensing ELR.

Based on SEA's roll simulator data, staff believes that the ANSI/OPEI B71.9-2016 and ANSI/ROHVA 1-2016 requirement for seat belts with ELRs will improve occupant protection and reduce injury severity in ROV-related rollover events.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2016 Section 12.2 Seat Belt Reminder and Speed-limiter** and **ANSI/OPEI B71.9-2016 Section 5.1.3.2 Seat Belt Reminder System** specify that ROVs shall be equipped with a reminder system that limits the vehicle's maximum speed to 15 mph, if the driver's seat belt is not buckled.

CPSC Staff's Evaluation

CPSC staff believes that a requirement for a seat belt reminder tied to vehicle speed will reduce deaths and injuries associated with ROVs by increasing seat belt use and maximizing occupant protection during a rollover event. CPSC staff's analysis of ROV-related incidents indicates that 91 percent of fatally ejected victims and 73 percent of all victims (fatal and nonfatal) were not wearing a seat belt at the time of the incident, when seatbelt use is known. Without seat belt use, occupants experience partial to full ejection from the ROV, and many victims are struck by the ROV after ejection.[33] SEA roll simulator test results of several model year 2009-2011 ROVs and follow-up tests on several model year 2014-2015 ROVs show that seat belt use, in conjunction with robust passive shoulder restraint, prevents occupant ejection during tripped and untripped rollovers of ROVs. ROHVA also performed an analysis of hazard and risk issues associated with ROV-related incidents and determined that lack of seat belt use is the top incident factor. ROHVA stated in a letter dated April 18, 2011: "Based on the engineering judgment of its members and its review of ROV incident data provided by the CPSC, ROHVA concludes that the vast majority of hazard patterns associated with ROV rollover would be eliminated through proper seat belt use alone." [34]

CPSC staff research shows that seat belt reminders that are annoying and persistent are the most effective method to increase seat belt use.[35] In particular, studies based on haptic feedback resistance showed almost 100 percent compliance when vehicle speed was tied to the seat belt reminder. Therefore, staff believes ROVs with a seat belt reminder that limits vehicle speed will be similarly effective. Staff also believes that 15 mph is a reasonable and acceptable maximum speed limit for an unbelted ROV driver because:

1) ANSI/NGCMA Z130.1 – 2004, American National Standard for Golf Carts – Safety and Performance Specifications, specifies the maximum speed for golf carts at 15 mph. Golf carts do not have seat belts or ROPS. This standard establishes 15 mph as the maximum acceptable speed for unbelted drivers and passengers in vehicles that are often driven in off-road conditions.
2) A focus group study of ROV user response to vehicle speed limitation based on seat belt use found that participants chose to drive an ROV without seat belts at an average speed of 14 mph, when the distance traveled was less than 100 feet.[36] This indicates that 15

[33] Some belted occupants also experience partial ejection from the ROVs, although the reports of this occurrence are rare.
[34] Yager, T. (2011) Letter to Caroleene Paul, dated April 18, 2011. Recreational Off-Highway Vehicle Association (ROHVA) written response to CPSC staff's ballot on proposed American National Standard ANSI/ROHVA 1-201X. p. 8. Retrieved from: http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/041811ROHVA1stBallotResponseLtrtoCPSConrevisiontovolstd.pdf.
[35] See Tab I in Briefing Package Notice of Proposed Rulemaking (NPR) for Recreational Off-Highway Vehicles (ROVs) in *Safety Standard for Recreational Off-Highway Vehicles (ROVs)*. Retrieved from: http://www.cpsc.gov/Global/Newsroom/FOIA/CommissionBriefingPackages/2014/SafetyStandardforRecreationalOff-HighwayVehicles-ProposedRule.pdf.
[36] Westat Final Report. (2015). User Acceptance and Effectiveness of Seat Belt Speed Limiters on Recreational Off-Highway Vehicles – Phase 2: Field Test Focus Group. Retrieved from: http://www.cpsc.gov/Global/Research-and-Statistics/Injury-Statistics/Sports-and-Recreation/ATVs/Westat-Phase-2-Final-report---User-Acceptance-of-Seat-Belt-Speed-Limiter-on-ROVs.pdf.

mph is a reasonable speed for ROV users to perform tasks at slow speeds without a seatbelt.

3) Current ROVs on the market with seat belt reminders tied to vehicle speed have a maximum speed limit of 15 mph when the driver's seat belt is unbuckled. These ROVs include model year 2015 Polaris Ranger and RZR vehicles, and model year 2013 and above BRP Commander vehicles.

Annex A of ANSI/ROHVA 1-2016 provides the rationale behind various requirements of the voluntary standard. The voluntary standard seat belt specification for only the driver's seat is based upon the principle that the ROV operator, in the role of "captain of the ship," is responsible for the safety of all vehicle occupants and will accordingly instruct passengers to use their seat belt. CPSC staff contracted Westat, Inc. (Westat) to conduct a survey of ROV seat belt use. Westat's report titled, "Observational Field Study of Seat Belt Use by Drivers and Passengers in Recreational Off-Highway Vehicles," showed the correlation between driver and passenger seat belt use is strong and statistically significant.[37] When the ROV driver was wearing a seat belt, the probability of the passenger wearing a seat belt was 94 percent.

CPSC staff believes that many of the ROV deaths and injuries can be reduced if front occupants are wearing seat belts because most of the ROV victims who were injured or killed (66 percent) were in a front seat of the ROV, either as a driver or passenger. Based on the SEA roll simulator tests showing the efficacy of seat belt use in keeping occupants inside an ROV during rollover, research that shows the efficacy of speed-limiting seat belt reminders, and the Westat observational report, which shows a strong correlation between driver and passenger seat belt use, staff believes that the ANSI/OPEI B71.9-2016 and ANSI/ROHVA 1-2016 requirement for a seat belt speed limiter that limits the vehicle speed to 15 mph if the driver's seat belt is not buckled will increase seat belt use in ROVs and reduce injuries and deaths caused by occupant ejection during ROV-related rollover events.

<u>Voluntary Standard Requirement:</u> **ANSI/ROHVA 1-2016 Section 12.3.1.2 Zone 2 Shoulder/Hip** and **ANSI/OPEI B71.9-2012 Section 5.1.4 Occupant Side Retention Devices** specify similar requirements for a side barrier in the shoulder area for ROV occupants to increase occupant retention. Both voluntary standards define a point, R, that is located 17 inches above the seating surface and 6 inches forward of the seat back. An outward sideways force of 163 lbf is applied through a 3-inch diameter disc probe at point R for 10 seconds. The performance requirement specifies that the side barrier shall not deflect more than 4 inches past the width of the vehicle after the force is applied.

<u>CPSC Staff's Evaluation</u>

CPSC staff believes that a requirement for a passive shoulder barrier will reduce deaths and injuries associated with ROV rollover events by maximizing occupant retention during a rollover event. CPSC staff contracted SEA to conduct dynamic occupant protection performance tests on

[37] Jenness, J. et al. (2015). Observational Field Study of Seat Belt Use by Drivers and Passengers in Recreational Off-Highway Vehicles. Retrieved from: http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/WestatObservationalStudyReportROVSeatBeltUseTask3.pdf.

several model year 2014-2015 ROVs and to conduct side barrier tests in accordance with the requirements in ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016.[31] CPSC staff also conducted side barrier probe tests to confirm results of SEA probe tests (see Appendix A).

The results of the dynamic occupant protection performance tests of model year 2014-2015 ROVs confirmed results of earlier tests of model year 2009-2011 ROVs[30] that showed best occupant protection performance in vehicles when seat belts are used in conjunction with a passive shoulder barrier restraint. CPSC staff considers the SEA dynamic occupant protection performance test as the best indicator of occupant excursion during a rollover event.

Results of the dynamic occupant protection performance tests and probe tests conducted by SEA and CPSC staff are shown below in Table 1:

Table 1. Results of Roll Simulator and Probe Tests.

Vehicle	Roll Sim Test – occupant head stays within ROPS		Side/Shoulder Side Design	SEA Probe Test	CPSC Probe Test
	Threshold	Tripped			
A15	*	*	rigid barrier	Pass	*
B15	*	*	tubing/bar	Pass	Pass
C15	N	Y	none	Fail	Fail
D15	*	*	net and bar	Pass	*
E15	Y	Y	rigid barrier	Pass	*
F15	*	*	door	Pass	*
H15	Y	Y	door	Pass	*
I15	*	*	net and bar	Pass	Fail
J15	Y	Y	net and bar	Fail	*
K15	*	*	door	Pass	Pass
L15	Y	N	net and bar	Fail	Fail
M15	Y	Y	net and bar	Pass	*

* Vehicle not tested because occupant protection configuration is similar to other vehicles tested or side barrier is door that past tests confirm will pass the occupant protection test.

Source: Zagorski, S. and Sidhu, A. (2016). Dynamic Occupant Protection Performance Tests for Recreational Off-Highway Vehicles (ROVs). Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/SEADynamicOccupantProtection.pdf and CPSC staff in-house testing (see Appendix A).

Test results confirm that the ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 side barrier performance tests eliminate vehicles that perform poorly in the dynamic occupant protection performance tests conducted by SEA.[38]

Comparisons of the test results also show that the probe test specifications used to locate the point of force application, Point R, can vary and affect whether the force is applied to a solid

[38] The probe test also eliminates Vehicle J, which performs well in the roll simulator tests, despite the presence of a passive barrier because Vehicle J is configured with a net at Point R and the net displaces more than 4 inches outside the vehicle width during the probe test.

structure of a passive barrier. Point R is measured from the ROV seat surface and back, but ROV seats vary in shape and contour. Therefore, the seating surface and seat back are not flat and perpendicular planes from which to define Cartesian coordinates for Point R. For example, Vehicle J15 is configured with a seat belt in conjunction with a net and bar for passive shoulder barrier restraint. Vehicle J15 performs well in the roll simulator tests, but Point R, as measured by SEA, is on the net portion of the side barrier and the vehicle fails the probe test. In the case of Vehicle I15, the vehicle is also configured with a seat belt in conjunction with a net and bar for passive shoulder barrier restraint. Roll simulation tests have shown that such a vehicle provides maximum occupant protection performance. SEA measured point R on the solid portion of the side barrier and the vehicle passed the probe test. However, CPSC staff measured point R on the net portion of the side barrier and the vehicle failed the probe test. Due to this variability of measuring point R, CPSC staff believes that the voluntary standard probe test may be more stringent than dynamic roll simulation tests in evaluating occupant protection performance.

Based on the SEA roll simulator tests showing the efficacy of seat belts used in conjunction with passive shoulder barrier restraints, and side barrier probe tests conducted by SEA and CPSC staff, staff believes that the ANSI/OPEI B71.9-2016 and ANSI/ROHVA 1-2016 side barrier performance requirements will increase occupant protection performance and reduce injuries and deaths caused by occupant ejection during ROV-related rollover events.

E. Compliance with Voluntary Standards.

ROV Market

Currently, there are two general varieties of ROVs: utility and recreational (see Figure 12 and Figure 13). Models emphasizing utility have larger cargo beds, higher cargo capacities, and lower top speeds. Models emphasizing recreation have smaller cargo beds, lower cargo capacities, and higher top speeds. Utility and recreational ROVs have a maximum speed that exceeds 30 mph.

Figure 12. Typical Utility ROV

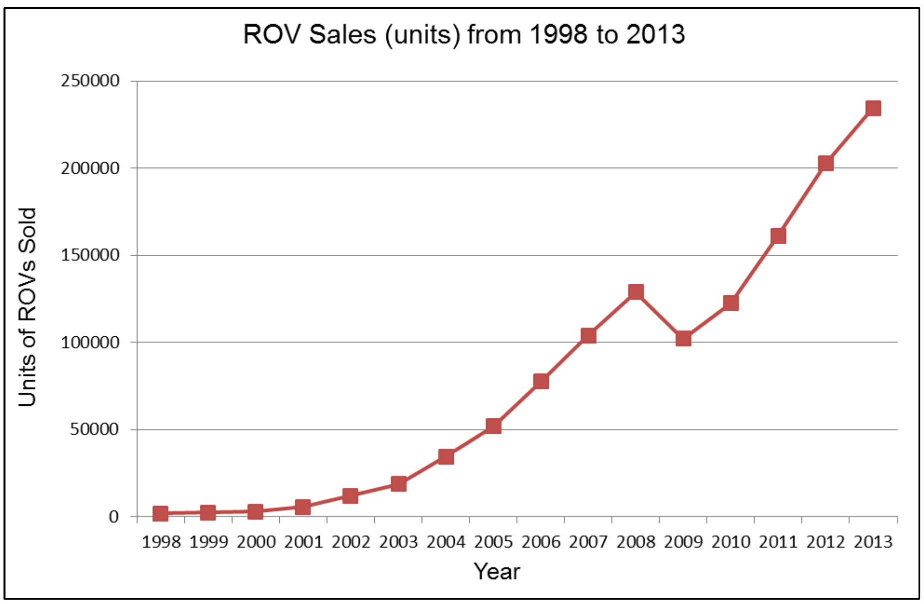
Figure 13. Typical Recreational ROV

ROHVA developed ANSI/ROHVA 1 *American National Standard for Recreational Off-Highway Vehicles* for recreation-oriented ROVs. ROHVA member companies include: Artic

Cat, BRP, Honda, John Deere, Kawasaki, Polaris, and Yamaha.[39] OPEI developed ANSI/OPEI B71.9, *American National Standard for Multipurpose Off-Highway Utility Vehicles,* for utility-oriented ROVs. OPEI member companies include: Honda, John Deere, Kawasaki, and Yamaha.[40]

The number of manufacturers marketing ROVs in the United States has increased substantially in recent years.[41] In 2013, there were 20 manufacturers known to CPSC to be supplying ROVs to the U.S. market. About 92 percent of ROVs sold in in the United States are manufactured in North America. About 7 percent of the ROVs sold in the United States are manufactured in China (by nine different manufacturers). Less than 1 percent of ROVs are produced in countries other than the United States or China.[42]

Sales of ROVs have increased substantially since their introduction (see Figure 14). The only dip in sales occurred around 2008. Otherwise, annual sales have increased from fewer than 2,000 units in 1998, to an estimated 234,000 units in 2013.[42] One manufacturer, Polaris Industries Inc., accounted for about 60 percent of the ROVs sold in the United States in 2013.



Source: CPSC analysis of data compiled by Power Products Marketing. Tab B of ROV NPR briefing package. Retrieved from: http://www.cpsc.gov/Global/Newsroom/FOIA/CommissionBriefingPackages/2014/SafetyStandardforRecreationalOff-HighwayVehicles-ProposedRule.pdf.

Figure 14. ROV Sales (units), 1998-2013

[39] ROHVA website retrieved from: http://www.rohva.org/.
[40] OPEI presentation to CPSC staff at November 2, 2010 public meeting. Retrieved from: http://www.cpsc.gov/PageFiles/80774/rohv11022010.pdf.
[41] Staff's most recent market information is from 2013.
[42] This information is based upon a staff analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2015).

ROV Market Compliance

ANSI/OPEI B71.9-2016 states that the "effective implementation date of this standard shall be two (2) years after the publication date and shall apply to all products built after that date. Manufacturers may also comply with this standard any time after [August 2, 2016]." ANSI/ROHVA 1-2016 states that the standard "becomes effective beginning with 2018 model year vehicles, but earlier compliance is permitted."

Staff tested and inspected 12 model year 2014 and 2015 ROVs, of which 11 were manufactured by ROHVA and/or OPEI members and one was manufactured by a foreign manufacturer (a company that was not a ROHVA or OPEI member). Results show that many vehicles pass one or more of the requirements in the 2016 version of the voluntary standards, but no vehicle passes all the voluntary standards requirements.[43] This lack of full compliance is not unexpected because the voluntary standards were revised after the test samples were manufactured and certain provisions, such as the hang tag and yaw rate tests, were not finalized until the standards were published in 2016.

Based on the active engagement of ROHVA and OPEI members in developing the voluntary standards for ROVs, and statements made by ROHVA and OPEI members of their intention to make changes to their products to comply with new requirements[44], CPSC staff believes ROVs sold by ROHVA and OPEI members will eventually comply with all the requirements of the 2016 versions of the voluntary standards. Staff compared ROHVA and OPEI member lists to North American manufacturing, and found only one manufacturer that might not be a member of either ROHVA or OPEI. The potential North American manufacturer that might not be a member of either trade association is Intimidator, Inc. However, Intimidator, Inc. (Intimidator) is a spin-off of Bad Boy Mowers, which is an OPEI member. Intimidator is a small manufacturer and staff believes that it accounts for a small percentage of ROVs sold in the United States.[45] Even assuming that Intimidator is not a member of OPEI or ROHVA, and making the conservative assumption that no foreign manufacturers comply with the voluntary standards, staff estimates compliance with the voluntary standard would still be about 90 percent of the market once the voluntary standards become effective.

In conclusion, CPSC staff believes ROV compliance with the voluntary standards is trending toward increased compliance, and staff expects over 90 percent compliance to the voluntary standards around the time of the effective dates of the two standards. This is based on the participation of the North American manufacturers (who sell more than 90 percent of the ROVs in the United States) in the ROHVA and OPEI standard development efforts and statements made regarding their intended compliance. Staff believes at least 90 percent of ROVs will comply with ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016, and that this 90 percent figure

[43] One vehicle manufactured by a foreign manufacturer failed almost all the new requirements that address ROV rollover and occupant protection.
[44] Oral Presentation by Paul Vitrano, Polaris Industries, Inc. before the U.S. Consumer Product Safety Commission CPSC Docket 2009-0087. Retrieved from: https://www.regulations.gov/document?D=CPSC-2009-0087-0730.
[45] Based upon a CPSC staff analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2015).

may be conservative because it assumes that all non-North American manufacturers will not comply with the new voluntary standards requirements.

III. CONCLUSION

As of August 26, 2016, CPSC staff is aware of 942 reported ROV-related incidents with at least one death or injury that occurred on or after January 1, 2003. There were 665 reported fatalities and 843 reported injuries related to these incidents. In 2012, CPSC staff conducted a multidisciplinary review of 428 ROV-related incidents resulting in at least one injury or death that occurred between January 1, 2003 and December 31, 2011, and reported to CPSC staff on or before December 31, 2011.[46] CPSC staff's analysis of the 428 incidents identified ROV rollover and occupant ejection as a dominant hazard pattern.

In June 2016, ROHVA and OPEI revised their respective voluntary standards to increase the lateral stability of ROVs, to prohibit oversteer vehicle handling that can lead to divergent instability, and to increase occupant retention within the protective zone of the ROPS of the vehicle during a rollover event. CPSC staff reviewed the revised requirements and determined that the voluntary standards will likely improve ROV safety by:

- Improving lateral stability with a requirement for a hang tag that displays the vehicle's rollover resistance metric;
- Improving vehicle handling with a requirement that prohibits divergent instability;
- Improving occupant protection performance with a requirement for a seat belt reminder that is tied to vehicle speed, and a requirement for side barriers in the shoulder area of ROV occupants to increase occupant retention.

Staff believes that the revised voluntary standards are likely to reduce the occurrence of ROV rollovers by increasing lateral stability and prohibiting divergent instability. In addition, staff believes the revised standards are likely to reduce the occurrence of occupant ejection during rollover events by increasing seat belt use and improving side retention. Therefore, staff believes the current voluntary standards will adequately address the risk of ROV rollover and occupant ejection.

Furthermore, staff estimates that at least 90 percent of ROVs will comply with ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 because ROHVA and OPEI members are the North American ROV manufacturers who participated in the development of the standard and sell more than 90 percent of the ROVs in the United States. Staff believes ROV manufacturer product compliance is trending toward increased compliance and staff expects over 90 percent compliance to the voluntary standards around the time of the effective dates of the two standards. For these reasons, staff recommends that the Commission terminate rulemaking on ROVs.

[46] Received as of December 31, 2011. All incident analysis is based on reported information.

Appendix A

Probe test results for vehicles B15, C15, I15, K15, and L15.

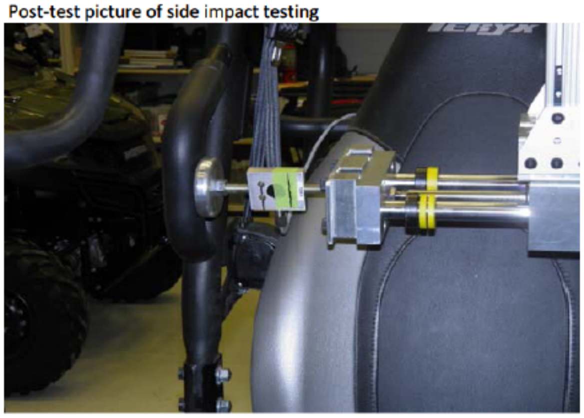
Recreational Off-Highway Vehicle (ROV) ANSI/ROHVA 1-201X					
Sample #:	Vehicle B15	**Tested By:**	LSM Staff	**Date:**	6/24/2016
Manufacturer:	[redacted]	**Importer:**	[redacted]	**Model:**	[redacted]

Equipment Required:

x	ROV Marking Fixture	x	ROV Pneumatic Fixture	x	Tape Measure	x	Three inch carboard disc
x	Laser Level (self aligning)	x	Pneumatic Controls	x	Paint Marker		
						Revision Date:	2/10/2016
						Version:	ROHVA 1-201X

Section	Requirement	Result	Comments
M = Requirements Met, NM = Not Met, NA = Not Applicable, NT = Not Tested			
12.3.2.3	Zone 2: Shoulder/Hip	M.	The structure did not deflect more than 101.6 mm.

Post-test picture of side impact testing



Recreational Off-Highway Vehicle (ROV) ANSI/ROHVA 1-201X							
Sample #: Vehicle C15		**Tested By:** LSM Staff		**Date:** 6/22/2016			
Manufacturer: [redacted]		**Importer:**		**Model:** [redacted]			
Equipment Required:							
x	ROV Marking Fixture	x	Tape Measure				
x	Three inch Cardboard disc	x	Paint Marker				
						Revision Date:	2/10/2016
						Version:	ROHVA 1-201X

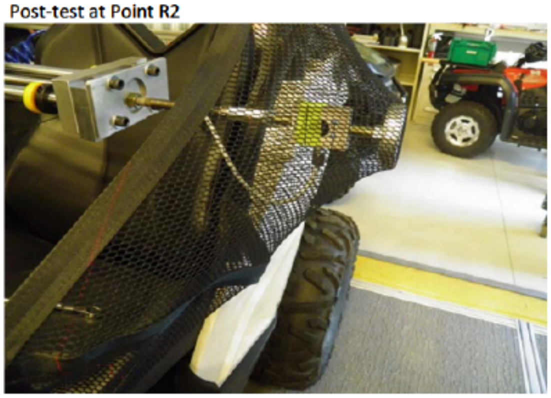
Section	Requirement	Result	Comments
M = Requirements Met, NM = Not Met, NA = Not Applicable, NT = Not Tested			
12.3.2.3	Zone 2: Shoulder/Hip	Not Met.	A 3-inch diameter circle surrounding Point R does not contact a restraint.

Point R on driver's side

Recreational Off-Highway Vehicle (ROV) ANSI/ROHVA 1-201X							
Sample #:	Vehicle I15	**Tested By:**	LSM Staff	**Date:**	6/22/2016		
Manufacturer:	[redacted]	**Importer:**	[redacted]	**Model:**	[redacted]		
Equipment Required:							
x	ROV Marking Fixture	x	ROV Pneumatic Fixture	x	Tape Measure	x	Three inch carboard disc
x	Laser Level (self aligning)	x	Pneumatic Controls	x	Paint Marker		
						Revision Date:	2/10/2016
						Version:	ROHVA 1-201X

Section	Requirement	Result	Comments
M = Requirements Met, NM = Not Met, NA = Not Applicable, NT = Not Tested			
12.3.2.3	Zone 2: Shoulder/Hip	Not Met.	The vehicle fails because the deflection exceeded the 101.6 mm requirement on Driver's side Point R2.

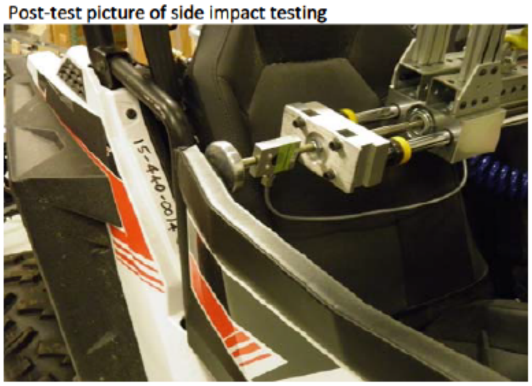
Post-test at Point R2



Recreational Off-Highway Vehicle (ROV) ANSI/ROHVA 1-201X							
Sample #:	Vehicle K15	Tested By:	LSM Staff		Date:	6/24/2016	
Manufacturer:	[redacted]	Importer:	[redacted] .		Model:	[redacted]	
Equipment Required:							
x	ROV Marking Fixture	x	ROV Pneumatic Fixture	x	Tape Measure	x	Three inch carboard disc
x	Laser Level (self aligning)	x	Pneumatic Controls	x	Paint Marker		
						Revision Date:	2/10/2016
						Version:	ROHVA 1-201X

Section	Requirement	Result	Comments
M = Requirements Met, NM = Not Met, NA = Not Applicable, NT = Not Tested			
12.3.2.3	Zone 2: Shoulder/Hip	M.	The lateral movement of the probe did not exceed the requirement on either side.

Post-test picture of side impact testing



Recreational Off-Highway Vehicle (ROV) ANSI/ROHVA 1-201X					
Sample #:	Vehicle L15	**Tested By:**	LSM Staff	**Date:**	6/23/2016
Manufacturer:	[redacted]	**Importer:**	[redacted]	**Model:**	[redacted]
Equipment Required:					
x	ROV Marking Fixture	x	Paint Marker		
x	Tape Measure	x	Three Inch Carboard disc		
				Revision Date:	2/10/2016
				Version:	ROHVA 1-201X

Section	Requirement	Result	Comments
M = Requirements Met, NM = Not Met, NA = Not Applicable, NT = Not Tested			
12.3.2.3	Zone 2: Shoulder/Hip	Not Met.	A 3-inch diameter circle surrounding Point R does not significantly contact the restraint.

Point R on Passenger's side