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May 23, 2014

Mr. Thomas S. Yager
Vice President
Recreational Off-Highway Vehicle Association
2 Jenner Street, Suite 150
Irvine, CA 92618-3806

Dear Mr. Yager:

U.S. Consumer Product Safety Commission (CPSC) staff appreciates the opportunity to comment on the Canvass Draft of the proposed American National Standard for Recreational Off-Highway Vehicles, ANSI/ROHVA 1-201X, received on March13, 2014.[1] As stated in staff's letter of August 29, 2013 to ROHVA in which staff recommended changes to the ANSI/ROHVA standard (please see attached), staff is aware of at least 231 deaths and 388 injuries associated with 428 ROV-related incidents (reported between January 1, 2003 and December 31, 2011). Staff is pleased to see ROHVA taking steps to improve the voluntary standard. However, CPSC staff believes the draft voluntary standard requirements will not reduce the number of deaths and injuries from ROVS, and staff encourages the ANSI/ROHVA committee to continue to improve the draft voluntary standard requirements for ROV dynamic stability, steering and handling, and occupant protection.

Dynamic Stability

Summary of Draft Provision. The Canvass Draft includes a change to the ANSI/ROHVA 1-2011 standard in Section 8. Lateral Stability, adding a new dynamic test for lateral stability. The added test is a J-turn maneuver performed at 30 mph with a steering wheel angle input of 110 degrees. The performance requirement states that eight out of 10 test runs shall not result in two-wheel lift (a precursor to rollover).

CPSC Staff's Comments. CPSC staff does not believe that the ANSI/ROHVA requirement accurately characterizes the lateral stability of the ROV. Nor can the requirement be

[1] The comments in this letter are those of the CPSC staff and have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

used to compare stability performance between two vehicles. Moreover, it is unclear how ROHVA arrived at a proposed 110 degrees of steering wheel input. CPSC staff is not aware of any standards, recognized test protocols, or real-world significance that supports using a J-turn maneuver with 110 degrees of steering input to assess the lateral stability of an ROV.

ROHVA's use of the J-turn does not measure the lateral acceleration at two-wheel lift that produces ROV rollover. Rollover in an ROV begins when the lateral acceleration builds to the point that the vehicle can no longer counterbalance the roll moment generated by the lateral acceleration.[2] Therefore, staff believes the lateral acceleration at two-wheel lift is the best indicator of the ROV's lateral stability. There is no correspondence between the proposed ANSI/ROHVA dynamic stability requirement and ROV lateral stability because the 110-degree steering wheel input does not correspond to a turning radius and an associated lateral acceleration. For example, an ROV with a low steering ratio will make a sharper turn at 110 degrees of steering wheel input than an ROV with a high steering ratio.[3] In the proposed ANSI/ROHVA J-turn test, a vehicle with a larger steering ratio will make a wider turn and generate less lateral acceleration than a vehicle with a smaller steering ratio.

As you know, CPSC contracted with SEA Limited (SEA) to evaluate ROVs. SEA's reports are available on CPSC's website (http://www.cpsc.gov/en/Research--Statistics/Sports--Recreation/ATVs/Technical-Reports/). CPSC has previously provided these reports to ROHVA. The results of J-turn tests conducted by SEA on 10 sample ROVs indicate that there is no correspondence between steering wheel input and lateral acceleration at two-wheel lift, as shown in Figure 1. For example, the lateral accelerations at two-wheel lift for Vehicles A, J, and I are 0.670 g, 0.670 g, and 0.675 g, respectively, with a standard deviation of .003 g, which is within 0.45 percent of the average value. If the steering wheel angle input corresponds to lateral acceleration, the steering wheel angles measured at two-wheel lift for Vehicles A, J, and I should be similarly within 1 percent of each other. However, the steering wheel angles measured for Vehicles A, J, and I are 95 degrees, 110 degrees, and 170 degrees, respectively, with a standard deviation of 40 degrees, which is a 32 percent variance from the average value. It is clear that the measured steering wheel angle does not correspond to the lateral acceleration value, and therefore, the steering wheel angle input cannot be used to compare or evaluate the rollover resistance of an ROV.

[2] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.309-311.

[3] The steering ratio relates the amount that the steering wheel is turned to the amount that the wheels of the vehicle turns. A higher steering ratio means the driver turns the steering wheel more to get the vehicle wheels to turn, and a lower steering ratio means the driver turns the steering wheel less to get the vehicle wheels to turn.

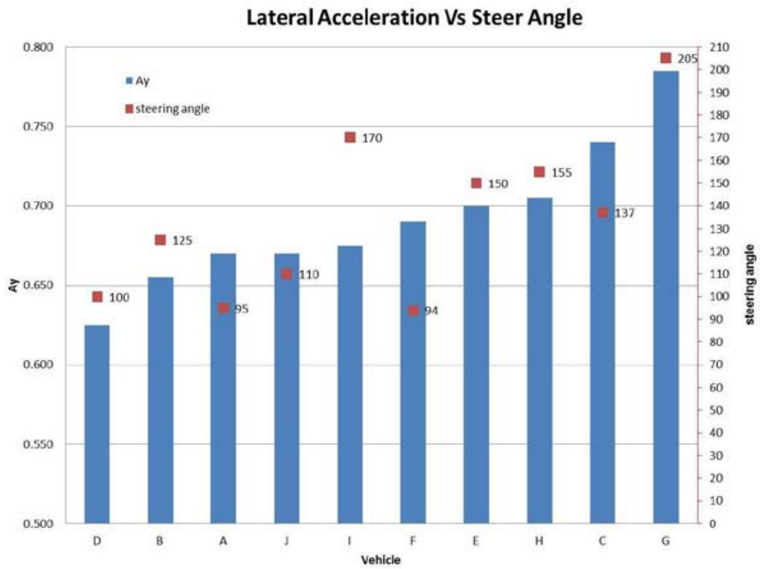

Figure 1. Lateral Acceleration and Steering Angle at Two-Wheel Lift for 30 mph J turn.
Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

CPSC staff is also concerned that ROHVA's proposed test introduces the effects of steering ratio into the outcome of the test.[4] The steering ratio is set by the ROV manufacturer and varies depending on make and model. Figure 2 shows the steering ratios of the 10 sample ROVs that were measured by SEA. If the dynamic lateral stability requirement is defined by a steering wheel angle input, a manufacturer could increase the steering ratio of a vehicle to meet the requirement rather than improve the vehicle's stability.

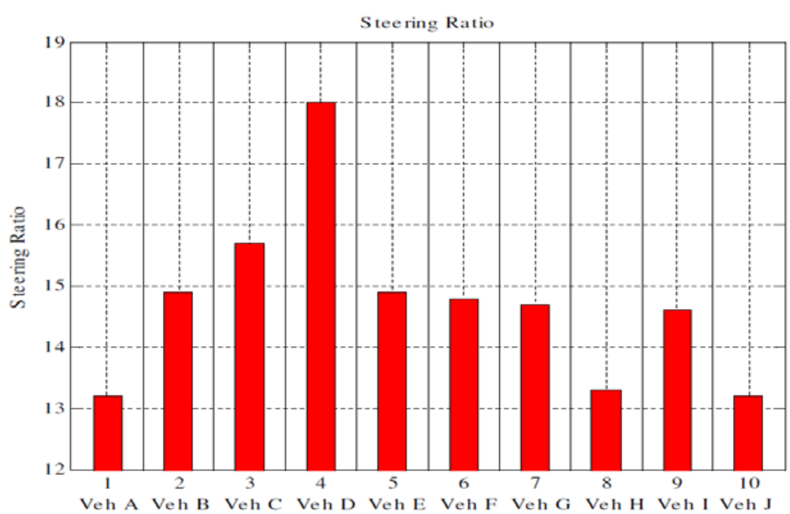

Figure 2. Steering Ratio = steering wheel input (degrees)/change in front wheel angle (degrees)
Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

[4] Staff expressed concern with the effects of steering ratio on the outcome of a J-turn test in a comment letter to OPEI dated April 14, 2011. Retrieved from http://www.cpsc.gov/PageFiles/117680/opei04142011.pdf.

For example, Vehicle A, with 0.670 g of lateral acceleration and 95 degrees of steering wheel angle at two-wheel lift, would fail the proposed ROHVA stability requirement because the steering wheel input at two-wheel lift is less than 110 degrees (see Figure 1). However, if the manufacturer changes the steering ratio of Vehicle A from 13.25 to 15.50, the steering wheel angle at two-wheel lift would increase to 111.6 degrees, and Vehicle A would pass the stability test without an increase in the 0.670 g lateral acceleration at two-wheel lift. Instead of increasing the roll resistance of the ROV, increasing the steer ratio would simply make the driver turn the steering wheel more to make a turn.

In conclusion, CPSC staff does not believe that ROHVA's proposed requirements for dynamic stability are a true measure of rollover resistance because measurement of steering wheel angle input appears to have no unique correspondence to lateral acceleration and introduces the effects of steer ratio into the measurement. Therefore, staff recommends a dynamic stability performance requirement that ROVs demonstrate a minimum lateral acceleration at two-wheel lift of 0.70 g or greater in a J-turn test conducted at 30 mph.

Rationale for CPSC staff's proposed requirement. The National Highway Traffic Safety Administration (NHTSA) developed the J-turn test protocol to measure the lateral acceleration of a vehicle at two-wheel lift and evaluate the vehicle's rollover resistance.[5] Lateral acceleration is the accepted measure by vehicle engineers to assess lateral stability or rollover resistance.[6] This value is commonly used by engineers to compare rollover resistance from one vehicle to another.

<u>Hangtag</u>

Summary of Draft Provision. The Canvass Draft includes a new hangtag requirement in Section 4. Vehicle (ROV) Equipment and Configuration. The proposal requires that every ROV offered for sale have a hangtag that provides general warning information and instructions for the consumer. In addition to current warnings, the proposed hangtag includes the following statements:

- ROV training courses are available, contact local dealer for information.
- Check with dealer for state or local laws regarding ROV operation.
- Hangtag not to be removed before sale.

CPSC Staff's Comments. CPSC staff does not believe that the ANSI/ROHVA hangtag requirement provides information to aid the consumer in the buying decision process for ROVs. The ANSI/ROHVA hangtag requirement duplicates warning and instruction information that is already affixed to the ROV and repeated in the owner's manual. CPSC staff is concerned that a hangtag with redundant warning information will dilute the important safety messages currently displayed on the ROV and in the owner's manual.

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[5] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.
[6] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.309-319.

CPSC staff believes a hangtag that is displayed at point of sale should provide the consumer with information that helps with the purchase decision. Information on a hangtag should be relevant to the purchase decision because hangtags are typically discarded after a product is purchased. For example, hangtag requirements in the voluntary standard for all-terrain vehicles (ATVs) provide information on the appropriate age recommendation for different sizes of ATVs, as well as information on the category of intended use.

CPSC staff believes the ANSI/ROHVA hangtag requirement should display each vehicle model's lateral acceleration at two-wheel lift, as measured by the J-turn test. The value should be displayed on a progressive scale to allow consumers to compare rollover resistance of each ROV before purchase. This information will allow a useful comparison of ROVs, whereas the draft ANSI/ROHVA provision only duplicates current information. Staff believes the additional statements proposed by ROHVA regarding training, local laws, and hangtag removal do not help consumers with the purchase decision and should be conveyed by some other method than a hangtag.

Rationale for CPSC staff's proposed requirement. CPSC staff believes that a hangtag should allow consumers to make informed decisions regarding the comparative lateral stability of ROVs when purchasing ROVs and should provide a competitive incentive for manufacturers to improve the rollover resistance of ROVs.

NHTSA believes that consumer information on the rollover risk of passenger cars will influence consumers to purchase vehicles with a lower rollover risk and inspire manufacturers to produce vehicles with a lower rollover risk.[7] In 2001, NHTSA began including rollover resistance information in its New Car Assessment Program (NCAP).[6] A subsequent study of static stability factor (SSF) trends in automobiles found that SSF values increased for all vehicles after 2001, particularly SUVs, which tended to have the worst SSF values in the years before 2001.[6] CPSC staff believes that a similar increase in rollover resistance can be achieved in ROVs by making the value of each model vehicle's lateral acceleration at two-wheel lift available to consumers. ROVs that exhibit higher lateral acceleration at two-wheel lift have a higher rollover resistance, and thus, these ROVs are more stable than ROVs with lower threshold lateral accelerations.

Vehicle Handling

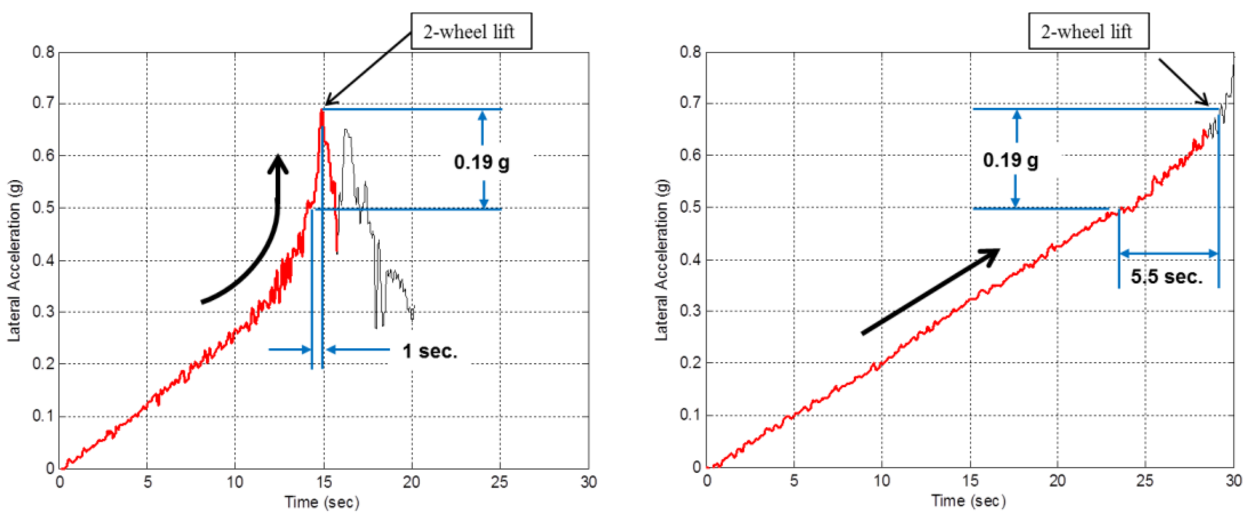
CPSC Staff's Comments. The Canvass Draft does not include requirements for vehicle handling. CPSC staff continues to believe that sub-limit oversteer is an undesirable and unstable steering condition for ROVs, and therefore, a requirement for understeer is necessary in the voluntary standard. Staff recommends a performance requirement that ROVs exhibit sub-limit understeer in the range of lateral acceleration from 0.10 g to 0.50 g when tested on a 100 ft. radius circle in a constant radius test, as described by SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*.

[7] 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.

Rationale for CPSC staff's proposed requirement. CPSC staff believes a requirement for sub-limit understeer is necessary to reduce ROV rollovers that may be produced by sub-limit oversteer. As related in SEA's report, tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition where the lateral acceleration increases suddenly and exponentially.[8] CPSC staff believes that this condition can lead to untripped ROV rollovers or can cause ROVs to slide into limit oversteer and experience tripped rollover.

Figure 3 shows plots of slowly increasing steer (SIS) tests conducted by SEA that illustrate the sudden increase in lateral acceleration.[9] The sudden increase in lateral acceleration is exponential and represents a dynamically unstable condition.[10] This condition is undesirable because it can cause a vehicle with low lateral stability (such as an ROV) to roll over suddenly.

In Figure 3, Vehicle A is an ROV that transitions to oversteer; Vehicle H is the same model ROV but a later model year in which the oversteer has been corrected to understeer.



Vehicle A (Oversteer) Vehicle H (Understeer)

Figure 3. SIS Plots of Lateral Acceleration Gain Over Time
Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased from 0.50 g to 0.69 g (a difference of 0.19 g) in less than 1 second and the vehicle rolled over. In contrast, Vehicle H never reached a point where the lateral acceleration increases exponentially because the condition does not develop in understeering vehicles. The increase in Vehicle H's lateral acceleration remains linear, and the lateral acceleration increase from 0.50 g to 0.69 g (same difference of 0.19 g) occurs in 5.5 seconds.

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[8] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D.
[9] The SIS test is also known as Constant Speed Variable Steer Angle Test and is described by SAE J266. During the test, the ROV driver maintains a constant speed of 30 mph and the vehicle's steering wheel angle is slowly increased at a rate of 5 degrees per second until the ROV rolls over. SEA conducted SIS tests on the sample of 10 ROVs.
[10] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.204-205.

CPSC staff believes ensuring sub-limit understeer will reduce rollover events because it eliminates the potential for sudden and exponential increase in lateral acceleration, a phenomenon associated with sub-limit oversteer, that can cause ROV rollovers. SEA test results indicate that half of the 10 sample ROVs tested exhibited sub-limit transitions to oversteer, and the other half exhibited a sub-limit understeer condition for the full range of the test.[11] CPSC staff believes this demonstrates that ROVs can be designed to understeer in sub-limit operation with minimum cost and without diminishing the utility or recreational value of this class of vehicle.

Occupant Protection

Summary of Draft Provision. The Canvass Draft includes a significant change to Section 11. Occupant Retention System (ORS), with the introduction of a reminder system that limits the vehicle speed to 15 miles per hour (mph) or less if the driver's seat belt is not buckled. The seat belt reminder requirements can be met by: (1) an audio and visual warning directed at the driver, or (2) a system that limits the vehicle speed.

CPSC Staff's Comments. CPSC staff is encouraged that ROHVA introduced specific performance requirements for in-vehicle technology that limits the maximum speed capability of the ROV until the driver's seat belt is buckled. However, staff believes that the vehicle speed limitation requirement for seat belt reminders should be mandatory, without the option of only an audio and visual warning. Based on staff's analysis of ROV-related incidents where victims were not wearing seat belts, staff also believes the requirement should include the seat belt status of front passengers as well as the driver.

In Annex A of the Canvass Draft, ROHVA states that a key consideration in evaluating a seat belt reminder system is its effectiveness in leading vehicle occupants to use their seat belts. ROHVA also states that studies and data indicate that continuous/repeating audible and visual reminders are effective in increasing seat belt use in automobiles. CPSC staff believes the automobile studies prove a more general point that seat belt reminders must be aggressive and acceptable to be effective. In the open environment of ROVs, staff believes engine noise and helmet use would reduce or negate the effectiveness of an audio warning. In addition, staff believes the visual reminder is ineffective because it is the least aggressive method of reminding a person to use their seat belt.

In conclusion, CPSC staff believes ROHVA's introduction of a reminder system that limits the maximum speed of the ROV until the driver's seat belt is buckled is a positive step toward increasing seat belt use in ROVs. However, staff also believes that ROHVA's optional requirement for only an audio and visual warning will be ineffective in the open environment of ROVs; therefore, staff believes a reminder system that limits the vehicle speed should be required.

[11] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf. Appendix B, page 24.

Rationale for CPSC staff's proposed requirement. As stated in CPSC staff's letter of August 29, 2013 to ROHVA, staff 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.[12] Without seat belt use, occupants experience partial to full ejection from the ROV, and many victims are struck by the ROV after ejection. Staff believes that many of the ROV deaths and injuries can be eliminated if occupants are wearing seat belts. 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. Therefore, staff believes a system that limits vehicle speed if occupied front seat belts are not buckled should be a mandatory requirement for all ROVs.

Thank you for this opportunity to comment on the Canvass Draft of the proposed ANSI/ROHVA 1-201x. CPSC staff remains committed to working with ROHVA to develop an effective revised voluntary standard that will reduce the deaths and injuries associated with ROVs. If you have any questions or comments, please feel free to contact me.

Sincerely,

Enc: Letter from Caroleene Paul to Paul Vitrano, dated August 29, 2013.

cc: Colin Church, CPSC Voluntary Standards Coordinator

[12] The percentages stated in this letter refer to incidents where the seat belt status (belted or not belted) is known, and the victims were reported to be in or on the ROV at the time of the incident.

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August 29, 2013

Mr. Paul Vitrano
Executive Vice President & General Counsel
Recreational Off-Highway Vehicle Association
2 Jenner Street, Suite 150
Irvine, California 92618-3806

Dear Mr. Vitrano:

The U.S. Consumer Product Safety Commission (CPSC) staff has participated in the Canvass Method used by the Recreational Off-Highway Vehicle Association (ROHVA) to develop the American National Standard, ANSI/ROHVA 1-2011 *Recreational Off-Highway Vehicles*.[1] In comment letters to the ballots for the draft proposed standards and draft proposed revision to the standard, CPSC staff has stated its concerns regarding the need for a ROV standard to have robust lateral stability requirements, vehicle handling requirements that ensure sub-limit understeer performance, and robust occupant protection requirements that maximize occupant retention performance.

CPSC staff urges the ANSI/ROHVA voluntary standard subcommittee to immediately consider incorporating the attached additional requirements and changes that staff suggests be made to the ANSI/ROHVA voluntary standard in order to improve ROV safety requirements for lateral stability, vehicle handling, and occupant protection. Please find enclosed the suggested requirements for your consideration in Appendix A.

A staff review of ROV-related incidents, as noted in Appendix B, occurring between January 1, 2003, and December 21, 2011, revealed 428 reported incidents resulting in 388 injured victims and 231 fatalities. CPSC staff looks forward to continuing to work with ROHVA to make these important changes to the ANSI/ROVHA voluntary standard to better address injuries and deaths associated with ROV rollover incidents. If you have any questions or comments, please feel free to contact me.

Sincerely,

Caroleene Paul

[1] The comments in this letter are those of the CPSC staff and have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

Appendix A: CPSC Staff Suggested Changes to ANSI/ROHVA 1-2011

A. Definitions

A.1 Recreational Off-Highway Vehicle (ROV). A motorized vehicle designed for off-highway use with the following features: four or more wheels with pneumatic tires; side-by-side seating for two or more occupants; automotive-type controls for steering, throttle, and braking; rollover protective structure (ROPS); seat restraint; and maximum speed capability greater than 30 mph.

A.2 Single-Hand Single-Operation Barrier. An occupant restraint component or assembly that is attached or actuated using a single operation with a single hand. As an example, a door may be opened using a single hand. A net system that requires the user to operate multiple attachment points to enter or exit the vehicle is not a single-hand single-operation barrier.

CPSC staff recommends that the following section, *Dynamic Lateral Stability*, replace section 8.3 *Dynamic Stability* in ANSI/ROHVA 1-2011.

B. Dynamic Lateral Stability

B.1 Test Surface. Tests shall be conducted on a dry, uniform, paved surface. Surfaces with irregularities, such as dips and large cracks, are unsuitable, as they may confound test results.

B.1.1 Friction. Surface used for dynamic testing shall have a peak braking coefficient greater than or equal to 0.90 and a sliding skid coefficient greater than or equal to 0.80 when measured in accordance with ASTM E 1337.

B.1.2 Slope. The test surface shall be flat and have a slope equal to or less than 1 degree (1.7%).

B.1.3 Ambient Conditions. The ambient temperature shall be between 0º Celsius (32 º Fahrenheit) and 40 º C (104 º F). The maximum wind speed shall be no greater than 8 m/s (18 mph).

B.2 Test Conditions.

B.2.1 Vehicle Condition. A vehicle used for dynamic testing shall be configured in the following manner.

(1) The test vehicle shall be a representative production vehicle. The ROV shall be in standard condition, without accessories. The ROV and components shall be assembled and adjusted according to the manufacturer's instructions and specifications.

(2) The vehicle shall be operated in two wheel drive mode with selectable differential locks off during the conduct of the tests. The tires shall be the manufacturer's original equipment tires. The tires shall be scuffed or lightly broken-in, but otherwise new. Heavily worn tires shall not be used for handling verification testing.

(3) Springs or shocks that have adjustable spring or damping rates shall be set to the manufacturer's recommended settings for delivery and general use.

(4) Tires shall be inflated to the ROV manufacturer's recommended settings for normal operation for the load condition specified in B.2.1(6). If more than one pressure is specified, the lowest value shall be used.

(5) All fluids shall be at the recommended level and the fuel tank shall be full at the rated capacity.

(6) The ROV shall be loaded such that the combined weight of the test operator, test equipment (including outriggers), and ballast, if any, shall equal 195 kg ± 5 kg (430 lbs ± 11 lbs) unless the ROV is intended for a single person, in which case the combined weight of the test operator, test equipment (including outriggers) and ballast, if any, shall equal 98 kg ± 5 kg (215 lbs ± 11 lbs) [note: the test operator weight may be less than 98 kg (215 lbs) so long as the combined weight of the test operator, test equipment (including outriggers) and ballast, if any, equals 98 kg ± 5 kg (215 lbs ± 11 lbs).

(7) The test loading condition shall simulate the test vehicle's center of gravity (CG) location, with the required load condition, to within a total of 1.0 inches, with the exception that the displacement of the CG z-axis may not be more than 0.5 inches in the positive direction in a z-down-positive coordinate system.

B.2.2 Vehicle Test Equipment.

B.2.2.1 Safety Equipment. Test vehicles shall be equipped with outrigger(s) on both sides of the vehicle. The outriggers shall be designed to minimally affect the loaded vehicle's center of gravity location and shall be capable of preventing a full vehicle rollover.

B.2.2.2 Steering Controller. The test vehicle shall be equipped with a programmable steering controller (PSC) capable of responding to vehicle speed, with a minimum steering angle input rate of 500 degrees per second, and accurate within ± 1 degree. The steering wheel setting for 0.0 degrees of steering angle is defined as the setting which controls the properly aligned vehicle to travel in a straight path on a level surface. The PSC shall be operated in absolute steering mode in that the amount of steering used for each test shall be measured relative to the PSC reading when the vehicle steering is at zero degrees.

B.2.2.3 Vehicle Instrumentation. The vehicle shall be instrumented to record lateral acceleration, vertical acceleration, forward speed, steering wheel angle, steering wheel angle rate, and vehicle roll angle. See Table 1 for instrumentation specifications. Ground plane lateral acceleration shall be calculated by correcting the body fixed acceleration for roll angle. Ground plane lateral acceleration shall also be corrected to reflect the value at the test vehicle center of gravity (CG) location. A roll motion inertia measurement sensor that provides direct output of ground plane lateral acceleration at the vehicle CG may also be used in lieu of manual correction to obtain ground plane lateral acceleration. Video with time display may be employed for the determination of two wheel lift. Roll angle may be calculated from roll rate data. Other instrumentation may be used to facilitate the processing of data or to collect other data not directly associated with the J-turn maneuver.

Table 1. Instrumentation Specification
For J-Turn and Turn Circle Testing of ROVs

Parameter	Accuracy
Vehicle Speed	± 0.10 mph
Acceleration (x, y, and z directions)	± 0.003 g
Steering Wheel Angle	± 0.25 deg.
Steering Wheel Angle Rate	± 0.5 deg./sec.
Pitch, Roll, and Yaw Rates	± 0.10 deg./sec.
Roll Angle*	± 0.20 deg.

* For turn circle testing roll angle must be measured directly or roll rate accuracy must be ± 0.01 deg./sec.

B.3 Test Procedure.

B.3.1 Set the vehicle drive train in its most-open setting. For example, two-wheel drive shall be used instead of four-wheel drive, and a lockable differential, if so equipped, shall be in its unlocked, or "open," setting.

B.3.2 Drive the vehicle in a straight path to define zero degree (0.0) steer angle.

B.3.3 Program the PSC to engage at 30 mph with an input steer angle of 90 degrees to the right, with a minimum steering angle input rate of 500 degrees per second. Program the PSC to hold steering angles for a minimum of 4 seconds before returning to zero. The steering rate when returning to zero may be less than 500 degrees per second.

B.3.4 Conduct a 30 mph drop throttle J-turn.

B.3.4.1 Accelerate the vehicle in a straight line to a speed greater than 30 mph.

B.3.4.2 As the vehicle approaches the desired test location, engage the PSC and release the throttle.

B.3.4.3 The PSC will input the programmed steering angle when the vehicle decelerates to 30 mph. Verify that the instrumentation recorded all data during this J-turn event.

B.3.5 Conduct additional J-turns, increasing the steer angle in 10 degree increments as Required until a two wheel lift event is achieved.

B.3.6 Conduct additional J-turns, decreasing the steering angle in 5 degree increments to find the lowest steering angle that will produce a two wheel lift event. Additional adjustments, up or down, in one degree increments may be utilized.

B.3.7 Repeat iterative process of conducting J-turns to determine minimum steer angle to produce two wheel lift in left turn direction.

B.3.8 Start the data acquisition system.

B.3.9 Conduct trials in the left and right directions using the minimum steering angles determined in Section 4.3.7 and 4.3.8 to verify that the steering angle produces two wheel lift events in both directions.

B.3.10 Conduct five trials with visually verified two wheel lift in the left and right turn directions and upslope and downslope directions, which will result in 20 total J-turn tests to complete the minimum data set. Review all data parameters for each trial to verify that all trials were correctly executed. Any trials that do not produce two wheel lift should be diagnosed for cause. If cause is identified, the data may be discarded and the trial should be repeated to replace the data. If no cause can be identified, repeat 4.3.5 through 4.3.7 to assure that the correct steering angle has been determined. Additional J-turn tests may be added to the minimum data set in groups of four with one test for each left/right turn direction and one test for each up/down slope direction on the test surface.

B.3.11 Determine LATERAL ACCELERATION THRESHOLD AT ROLLOVER value.

B.3.11.1 Data recorded in section B.3.10 shall be digitally low-pass filtered to 2.0 hertz using a phaseless, eighth order, Butterworth filter to eliminate noise artifacts in the data.

B.3.11.2 Plot data for ground plane lateral acceleration corrected to the test vehicle CG location, hand-wheel steer angle, and roll angle recorded for each trial in section B.3.10.

B.3.11.3 Find and record the peak ground plane lateral acceleration occurring between the time of the steering input and the time of two wheel lift and having a duration of at least 0.1 seconds.

B.3.11.4 If a body-fixed acceleration sensor is used, correct the lateral acceleration data for roll angle using the method described in the standard ANSI/ROHVA 1-2011:

Calculate ground-referenced lateral acceleration for each data sample. The data for Ay, Az, and roll angle are measured in the vehicle XYZ coordinate system (as defined in SAE J670 ® Vehicle Dynamics Terminology). The corrected lateral acceleration (Ay ground) shall be calculated by:

Ay ground = Ay cos Phi – Az sin Phi

B.4 Performance Requirements. The minimum value for the LATERAL ACCELERATION THRESHOLD AT ROLLOVER shall be 0.70 g or greater.

CPSC staff recommends that the following section, *Consumer Information Requirements*, be added to ANSI/ROHVA 1-2011.

B.5 Consumer Information Requirements. Every ROV shall be offered for sale with a hang tag that provides information on the LATERAL ACCELERATION THRESHOLD AT ROLLOVER value of that model vehicle. The tag shall be attached to the ROV and may only be removed by the first purchaser.

B.5.1 Size. Every hang tag shall be at least 6 inches (152 mm) wide by 4 inches (102 mm) tall.

B.5.2 Content. At a minimum, every hang tag shall contain the following.

B.5.2.1 The LATERAL ACCELERATION THRESHOLD AT ROLLOVER value of the vehicle on a progressive scale.

B.5.2.2 The statement – "**Compare** with other vehicles before you buy."

B.5.2.3 The statement – "This is a measure of the vehicle's resistance to rolling over on a flat surface. ROVs with higher numbers are more stable."

B.5.2.4 The statement – "Other vehicles may have a higher rollover resistance; compare before you buy."

B.5.2.5 The statement – "Rollover cannot be completely eliminated for any vehicle."

B.5.2.6 The statement – " Minimally accepted lateral acceleration is 0.7 g's during a J-turn test."

B.5.3 Format. The hang tag shall include the content and substantially the same format as shown in Figure 1.

B.5.4 Attachment. Every hang tag shall be attached to the ROV in such a manner as to be conspicuous and removable only with deliberate effort.

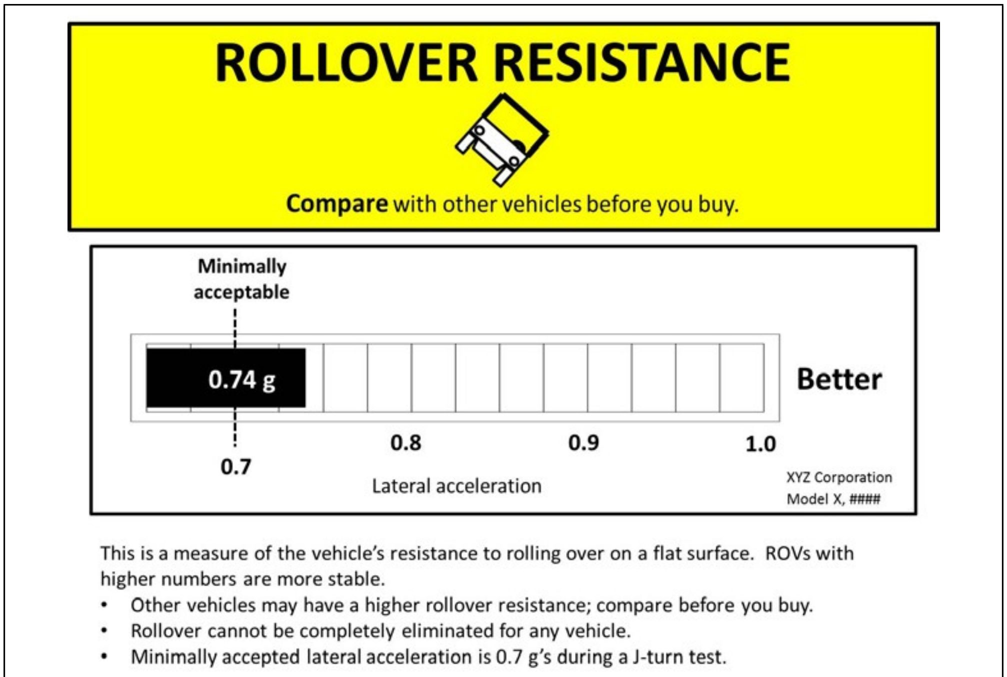

Figure 1. ROV Hang Tag (note: not shown to scale)

CPSC staff recommends that the following section, *Vehicle Handling*, be added to ANSI/ROHVA 1-2011.

C. Vehicle Handling

C.1 Test Surface. Tests shall be conducted on a dry, uniform, paved surface. Surfaces with irregularities, such as dips and large cracks, are unsuitable, as they may confound test results.

C.1.1 Friction. Surface used for dynamic testing shall have a peak braking coefficient greater than or equal to 0.90 and a sliding skid coefficient greater than or equal to 0.80 when measured in accordance with ASTM E 1337.

C.1.2 Slope. The test surface shall be flat and have a slope equal to or less than 1 degree (1.7 %).

C.1.3 Ambient Conditions. The ambient temperature shall be between 0º C (32 º F) and 40 º C (104 º F). The maximum wind speed shall be no greater than 8 m/s (18 mph).

C.2 Test Conditions.

C.2.1 Vehicle Condition. A vehicle used for dynamic testing shall be configured in the following manner.

(1) The test vehicle shall be a representative production vehicle. The ROV shall be in standard condition, without accessories. The ROV and components shall be assembled and adjusted according to the manufacturer's instructions and specifications.

(2) The vehicle shall be operated in two wheel drive mode with selectable differential locks off during the conduct of the tests. The tires shall be the manufacturer's original equipment tires. The tires shall be scuffed or lightly broken-in, but otherwise new. Heavily worn tires shall not be used for handling verification testing.

(3) Springs or shocks that have adjustable spring or damping rates shall be set to the manufacturer's recommended settings for delivery and general use.

(4) Tires shall be inflated to the ROV manufacturer's recommended settings for normal operation for the load condition specified in C.2.1(6). If more than one pressure is specified, the lowest value shall be used.

(5) All fluids shall be at the recommended level and the fuel tank shall be full at the rated capacity.

(6) The ROV shall be loaded such that the combined weight of the test operator, test equipment (including outriggers), and ballast, if any, shall equal 195 kg ± 5 kg (430 lbs ± 11 lbs) unless the ROV is intended for a single person, in which case the combined weight of the test operator, test equipment (including outriggers) and ballast, if any, shall equal 98 kg ± 5 kg (215 lbs ± 11 lbs) [note: the test operator weight may be less than 98 kg (215 lbs) so long as the combined weight of the test operator, test equipment (including outriggers) and ballast, if any, equals 98 kg ± 5 kg (215 lbs ± 11 lbs).

(7) The test loading condition shall simulate the test vehicle's center of gravity (CG) location, with the required load condition, to within a total of 1.0 inches, with the exception that the displacement of the CG z-axis may not be more than 0.5 inches in the positive direction in a z-down-positive coordinate system.

C.2.2 Vehicle Test Equipment.

C.2.2.1 Safety Equipment. Test vehicles shall be equipped with outrigger(s) on both sides of the vehicle. The outriggers shall be designed to minimally affect the loaded vehicle's center of gravity location and shall be strong enough to prevent vehicle rollover.

C.2.2.2 Vehicle Instrumentation. The vehicle shall be instrumented to record lateral acceleration, vertical acceleration, forward speed, steering wheel angle, steering wheel angle rate, and vehicle roll angle. See Table 1 for instrumentation specifications. Lateral acceleration shall be corrected for roll angle and to reflect the value at the center of gravity location. A roll motion inertia measurement sensor that provides direct output of ground plane lateral acceleration at the vehicle CG may also be used in lieu of manual correction to obtain ground plane lateral acceleration. Other instrumentation may be used to facilitate the processing of data or to collect other data not directly associated with the vehicle handling test maneuver.

C.3 Test Procedure.

C.3.1 Handling performance testing shall be conducted using the constant radius test method described in SAE Surface Vehicle Recommended Practice J266. The minimum radius for constant radius testing shall be 100 feet. In this test method the instrumented and loaded vehicle is driven around a constant radius circle marked on the test surface with the driver making every effort to maintain compliance of the vehicle path relative to the circle. The vehicle is operated at a variety of increasing speeds and data is recorded for those various speed conditions in order to obtain data to describe the vehicle handling behavior across the prescribed range of ground plane lateral accelerations. Data shall be recorded for the lateral acceleration range from 0.0 g to 0.6 g.

C.3.2 Start the data acquisition system.

C.3.3 Drive the vehicle on the circular path at the lowest possible speed. Data shall be recorded with the steering wheel position and throttle position fixed to record the approximate Ackerman angle.

C.3.4 Continue driving the vehicle to the next speed at which data will be taken. The level of lateral acceleration shall be increased and data shall be taken until it is no longer possible to maintain steady-state conditions. It is recommended that the test be repeated several times, so that results can be examined for repeatability and averaged.

C.3.5 Data Collection, Method 1 – Discrete Data Points. In this data acquisition method, the driver maintains a constant speed while maintaining compliance with the circular path and data points are recorded when a relatively stable condition is achieved. After the desired data points are recorded for a given speed, the driver accelerates to the next desired speed setting, maintains constant speed and compliance with the path, and data points are recorded for the new speed setting. This process is repeated for all speed settings required to map the lateral acceleration range from near 0.0 g to 0.6 g. Increments of speed shall be 1 to 2 miles per hour, to allow for a complete definition of the understeer gradient. Data shall be taken at the lowest speed practicable to obtain an approximation of the vehicle's Ackerman steering angle. Driver work load is high for this test method; therefore, data point selection should be accomplished by an observer that is not aboard the vehicle.

C.3.6 Data Collection, Method 2 – Continuous Data Points. In this data acquisition method, the driver maintains compliance with the circular path while slowly increasing vehicle speed and data from the vehicle instrumentation is recorded continuously, so long as the vehicle remains on radius. The rate of speed increase shall not exceed 0.93 mph (1.5 km/h) per second. Initial speed should be as low as is practicable to obtain an approximation of the vehicle's Ackerman steering angle. The speed range must be sufficient to produce corrected lateral accelerations from near 0.0 g to 0.6 g. Data above the target value for ground plane lateral acceleration is required to produce a representative curve fit of the data.

C.3.7 Vehicle Dimension Coordinate System. The coordinate system described in SAE Surface Vehicle Recommended Practice J670 shall be used.

C.3.8 Data Analysis. The lateral acceleration data shall be corrected for roll angle using the ROHVA method described in the standard ANSI ROHVA 1 - 2011. The ground plane lateral acceleration shall also be corrected to reflect the value at the test vehicle's center of gravity. The data shall be digitally low-pass filtered to 1.0 Hz using a phaseless, eighth-order, Butterworth filter and plotted with ground plane lateral acceleration on the abscissa versus steering wheel angle (not road wheel steer angle) on the ordinate. A second-order polynomial curve fit to the data shall be constructed in the range from 0.01 g to 0.50 g. The slope of the constructed graph determines the understeer gradient value in the units of degrees of steering wheel angle per g of ground plane lateral acceleration (degrees/g). Using the coordinate system specified in C.3.7, positive values for understeer gradient are required for values of ground plane lateral acceleration values from 0.10 g to 0.50 g.

C.4 Performance Requirements. Using the coordinate system specified in section C.3.7, values for the understeer gradient shall be positive for values of ground plane lateral acceleration values from 0.10 g to 0.50 g. Negative understeer gradients (oversteer) shall not be exhibited by the vehicle in the lateral acceleration range specified.

D. Occupant Retention System

<u>CPSC staff recommends that the following section, *Seat Belt Reminder System*, that requires seat belt use when using the ROV at speeds over 15 mph, replace section 11.2 *Seat Belt Reminder* in ANSI/ROHVA 1-2011.</u>

D.1 Seat Belt Reminder System. Manufacturers shall provide a seat belt reminder system that limits the maximum speed capability of the vehicle if the driver's seat belt and any occupied front passenger seat belt is not buckled. Visible feedback shall inform the driver that vehicle speed is limited until the seat belts of occupied seats are buckled.

D.1.1 Test Condition 1. Test conditions shall be as follows:

(1) ROV test weight shall be the vehicle curb weight with the test operator only. If the test operator weighs less than 98 kg (215 lbs), then the difference in weight shall be added to the vehicle to reflect an operator weight of 98 kg (215 lbs).
(2) Tires shall be inflated to the pressures recommended by the ROV manufacturer for the vehicle test weight.
(3) The test surface shall be clean, dry, smooth asphalt or concrete of less than a 1 degree (1.7%) grade.
(4) The driver's seat belt of the OEM vehicle shall not be buckled; however, the driver shall be restrained by a redundant restraint system for test safety purposes.

D.1.2 Test Condition 2. Test conditions shall be as follows:

(1) ROV test weight shall be the vehicle curb weight with the test operator and test weight in the front passenger seat only. If the test operator weighs less than 98 kg (215 lbs), then the difference in weight shall be added to the vehicle to reflect an operator weight of 98 kg (215 lbs). The passenger seat test weight shall be heavy enough to activate the passenger presence sensor.
(2) Tires shall be inflated to the pressures recommended by the ROV manufacturer for the vehicle test weight.
(3) The test surface shall be clean, dry, smooth asphalt or concrete of less than a 1 degree (1.7%) grade.
(4) The driver's seat belt shall be buckled. The passenger's seat belt shall not be buckled.

D.1.3 Test Procedure. Measure the maximum speed capability of the ROV under Test Condition 1 specified in D.1.1 and Test Condition 2 specified in D.1.2 using a radar gun or equivalent method. The test operator shall accelerate the ROV until maximum speed is reached, and shall maintain maximum speed for at least 15 m (50 ft). Speed measurement shall be made when the ROV has reached a stabilized maximum speed. A maximum speed capability test shall consist of a minimum of two measurement test runs conducted over the same track, one each in opposite directions. If more than two measurement runs are made there shall be an equal number of runs in each direction. The maximum speed capability of the ROV shall be the arithmetic average (mean) of the measurements made. A reasonable number of preliminary runs may be made prior to conducting a recorded test.

D.1.4 Maximum Speed-Limited Capability Requirement. The maximum speed capability of a vehicle with an unbuckled seat belt of the driver or any occupied front passenger seat shall be 15 mph or less.

CPSC staff recommends that the following section, *Occupant Retention Zone*, that requires a shoulder/hip zone be tested using a probe, replace section 11.3.1.2 *Zone 2- Shoulder/Hip* in ANSI/ROHVA 1-2011. CPSC staff also recommends that section 11.3.1.3 *Zone 3 – Arm/Hand* be tested using only method (A) Construction-Based Method.

D.2 Occupant Retention System Zone. Each vehicle shall restrict occupant egress and excursion for each zone through passive vehicle features.

D.2.1 General Test Conditions.

(1) Probes shall be allowed to rotate through a universal joint.
(2) Forces shall be quasi-statically applied and held for an additional 10 seconds.

D.2.2 Shoulder/Hip Zone. Retention requirements for Zone 2 shall be met by a passive barrier or structure or single-hand single-operation barrier or structure, approximately represented by the dashed lines in Figure 2, meeting the performance requirements of D.2.2.1. Such a barrier shall encompass point R when viewed from the side of the vehicle as shown in Figure 2. All measurements for the point shall be taken with respect to the base of the seatback. The base of the seatback lies on the surface of the seat base along the centerline of the seating position and is measured without simulated occupant weight on the seat. Point R is located 432 mm (17 inches) along the seatback above the base of the seatback. The point is 152 mm (6 inches) forward of and perpendicular to the seatback surface as shown in the figure. For an adjustable seat, Point R is determined with the seat adjusted to the rear-most position. Point R2 applies to an adjustable seat and is located in the same manner as Point R except that the seat is located in the forward-most position.

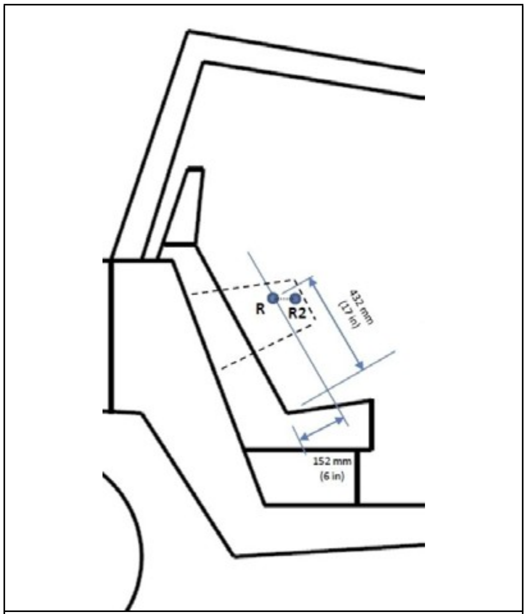

Figure 2. Point R in Shoulder/Hip Zone

D.2.2.1 Shoulder/Hip Performance Requirements. A barrier for the Shoulder/Hip zone shall be capable of withstanding a horizontal, outward force of 725 N (163 lbf). The force shall be applied through the upper arm probe shown in Figure 3. The upper arm probe shall be oriented so that Point Q on the probe is coincident with Point R for a vehicle with a fixed seat or Point Q shall be coincident with Point R2 for a vehicle with an adjustable seat. The probe's major axis shall be parallel to the seatback angle at a point 17 inches along the seat back above the base of the seatback. There shall be no deflection greater than 25 mm (1 in) upon application and removal of the force.

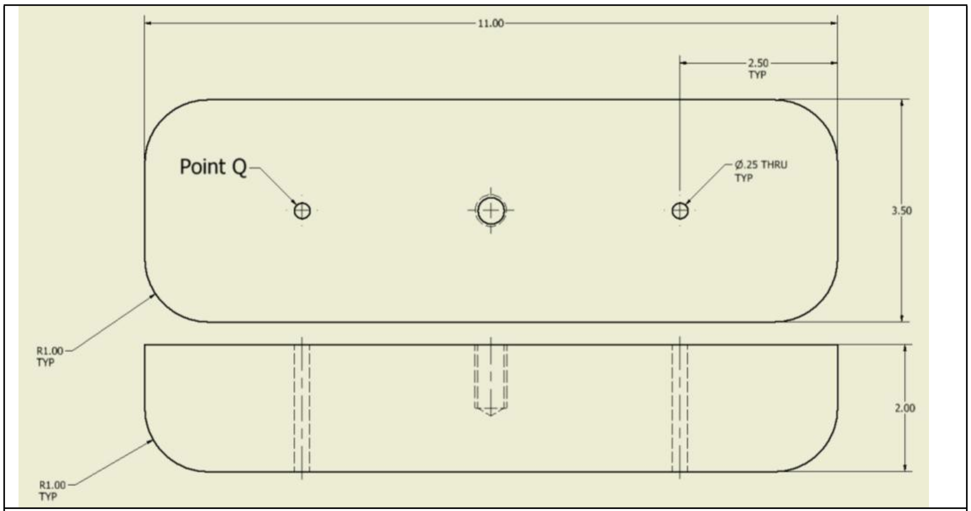

Figure 3. Shoulder/Hip Zone Probe

Appendix B: Summary of Incident Data and Hazard Characteristics

Reported Incidents

CPSC staff reviewed 428 ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases occurring between January 1, 2003 and December 31, 2011. From the 428 reported incidents, there were 388 injured victims and 231 fatalities. Children younger than 16 years of age made up 23 percent of the injured victims and 33 percent of the fatalities.

Of the 428 ROV-related incidents, 76 involved drivers under 16 years of age (18 percent), 227 involved adult drivers, aged 16 years or older (53 percent), and 125 involved drivers of unknown age (29 percent). Of the 227 incidents involving adult drivers, 86 (38 percent) are known to have involved the driver consuming at least one alcoholic beverage prior to the incident, 52 (23 percent) did not involve alcohol, and 89 (39 percent) have an unknown alcohol status of the driver.

Of the 619 victims who were injured or killed, most (66 percent) were in a front seat of the ROV, either as a driver or passenger, when the incidents occurred.

In many of the ROV-related incidents resulting in at least one death, CPSC staff was able to obtain more detailed information on the events surrounding the incident through an in-depth investigation (IDI). Of the 428 ROV-related incidents, 224 involved at least one death. This includes 218 incidents resulting in one fatality, 5 incidents resulting in two fatalities, and 1 incident resulting in three fatalities for a total of 231 fatalities.

Of the 224 fatal incidents, 145 (65 percent) did not occur on a paved surface, 38 (17 percent) did occur on a paved surfaced, and 41 (18 percent) occurred on unknown terrain surface.

Hazard Characteristics

CPSC staff considered incident characteristics that related to the design of the vehicle.

Lateral Rollover

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

Occupant Ejection and Seat Belt Use

From the 428 ROV-related incidents reviewed by CPSC staff, 817 victims were reported to be in or on the ROV during the incident and 610 (75 percent) were known to have been injured or killed. Of the 610 fatal and non-fatal victims that were known to be in or on the ROV at the time of the incident, 433 (73 percent) were known to have been partially or fully ejected from the ROV and 269 (62 percent) of these victims were hit by a part of the vehicle, such as the roll cage or side of the ROV. In addition, of these 610 victims, seat belt use is known for 477 victims and 348 (73 percent) were not wearing a seat belt at the time of the incident.

Of the 231 reported fatalities, 225 victims from 224 incidents were in or on the vehicle at the time of the incident. Twenty-seven percent of these fatal incidents (61 out of 224) involved drivers younger than 16 years of age. 194 (86 percent of the 225 victims in or on the vehicle) were ejected partially or fully from the vehicle. Of these 194 ejected victims, 141 (73 percent) were not wearing a seat belt, 14 (7 percent) were wearing seat belts, and 39 (20 percent) have an unknown seatbelt use status.

National Electronic Injury Surveillance System (NEISS)

A total of 2,018 injuries that were related to all-terrain vehicles (ATVs) or utility vehicles were recorded in the National Electronic Injury Surveillance System (NEISS) between January 1, 2010 and August 31, 2010. For each injury, a survey was attempted to obtain further information on the vehicle involved, the victim, and the characteristics of the incident.

A total of 688 surveys were completed, resulting in a 33 percent response rate for this survey. Of the 688 completed surveys, 17 were identified as involving an ROV due to the make and model of the vehicle involved. It is possible that more cases involved an ROV but were unable to be identified due to lack of information on the vehicle make and model.

The estimated number of emergency department-treated ROV-related injuries occurring in the U.S. between January 1, 2010 and August 31, 2010 is 2,300 injuries. Extrapolating for the year 2010, the estimated number of emergency department-treated ROV-related injuries is 3,200 with a corresponding 95 percent confidence interval of 1,300 to 5,100.