

**LOG OF MEETING
DIRECTORATE FOR ENGINEERING SCIENCES**

SUBJECT: Recreational Off-Highway Vehicles (ROVs) – Meeting requested by the Recreational Off-Highway Vehicle Association (ROHVA) to discuss their progress on dynamic test development and their progress on revising the ROHVA standard.

DATE OF MEETING: October 7, 2010

PLACE OF MEETING: U.S. Consumer Product Safety Commission, Bethesda, MD

LOG ENTRY SOURCE: Caroleene Paul, ESME *CP*

COMMISSION ATTENDEES: See attached attendance list

NON-COMMISSION ATTENDEES: See attached attendance list

SUMMARY OF MEETING:

Representatives of the Recreational Off-Highway Vehicle Association (ROHVA) met with CPSC staff to discuss ROHVA's latest standards development work and safety initiatives.

CPSC staff opened the meeting by setting the following ground rules:

- ROHVA requested this meeting with CPSC staff so although the meeting is public, discussions are limited to ROHVA representatives and CPSC staff/representatives.
- The opinions or views expressed by CPSC staff have not been reviewed or approved by the Commission and may not reflect the views of the Commission.
- The discussions during the meeting will be treated as comments to the ongoing rulemaking and will become part of the public record.

ROHVA representatives presented an overview of their approach to addressing occupant protection in ROVs, their position on dynamic vehicle testing as it applies to ROVs, and their development of dynamic tests to evaluate rollover propensity for ROVs (see attached presentation).

The following points were made regarding occupant protection:

- An analysis of top incident factors by Heiden Associates (product safety consultant retained by ROHVA) found that seat belts were not worn in 85% of ROV incidents and helmets were not worn in 83% of ROV incidents.
- ROHVA intends to update and standardize warning labels that will warn users to wear seat belts and helmets.
- ROHVA proposes zone based requirements to address foot/leg area (Zone 1), shoulder/hip area (Zone 2), hand/arm area (Zone 3), and head (Zone 4). Passive and active systems will be considered and include roll over protective structures (ROPS), seat belts, hand holds, foot/leg retention, hip/shoulder retention, and seats/headrests.

- Occupant Retention considerations include visibility, mobility, usage, and environmental effects.

The following points were made regarding dynamic testing of ROVs:

- Dynamic Research Institute (DRI) was retained to design a simple and repeatable dynamic test to evaluate rollover resistance of ROVs.
- A repeatable and reproducible off-highway surface does not exist.
- DRI developed the Roll Resistance Margin equation which uses a tire/soil coefficient defined as the maximum lateral acceleration achievable on soil. The value of this coefficient (0.55) is based on measurements made by DRI at 20 ATV ride sites in the late 1980s. The roll resistance equation is:

$$\text{Roll Resistance Margin} = \left(\frac{\text{Lateral Acceleration}_{2 \text{ wheel lift}}}{\text{tire/soil coefficient}} - 1 \right) \times 100\%$$

- DRI believes a roll resistance margin of 9% (minimum lateral acceleration at two wheel lift in the region of 0.60 g) provides an appropriate balance between roll resistance and off-highway mobility.
- DRI is opposed to using the test protocols in SAE J266 *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks* because SAE J266 measures steering characteristics and not roll stability.
- DRI is opposed to using J-Turn type tests such as ISO 7401 because the maneuver involves a transient steer input and the use of a steering robot (which adds complexity and cost to the testing), and repeatability would be difficult to achieve. DRI also believes speeds above 30mph on pavement introduces undesirable dynamics (such as loss of traction at rear wheels) that are not encountered in off-highway environments.
- DRI developed a constant steering wheel angle test where the steering wheel of the test vehicle is locked at a small steer angle (20 ft radius circle) and accelerated by a test driver until 2 wheel lift occurs or 2 wheel spin/spiral-in occurs. The tests were conducted on asphalt.
- DRI tested the Arctic Cat Prowler 700 XTX (MY 2010), Can Am Commander (MY 2011), Polaris Ranger RZR 800 (MY 2011), Polaris Ranger RZR S 800 (MY 2011), and the Polaris Ranger XP 800 (MY 2011).
- CPSC staff asked if DRI had performed any J-turn tests. DRI replied that they have not.
- CPSC staff asked what the pass/fail criteria is for DRI's proposed constant steer test. DRI responded that a pass/fail criteria has not been established yet.
- CPSC staff asked for a draft of the test protocol used by DRI. DRI replied that a copy would be forwarded to CPSC.
- CPSC representative, Dr. Greg Schultz (Aberdeen Test Center), made the following comments:
 - DRI's proposed dynamic test is essentially the constant steer angle test described in SAE J266 (Method 2 – *Constant steering wheel angle test*).
 - By limiting the test to such a small radius, the vehicles are power limited and the results will not reflect the full range of the vehicle's characteristics.

- There is a fundamental correlation between vehicle stability and vehicle steering gradient.
- CPSC representative, Gary Heydinger (SEA Limited), made the following comments:
 - The J-Turn maneuver is very useful in evaluating tip over.
 - J-Turn tests can be done without steering robots and still give repeatable results.
 - Loss of traction at the rear wheels is an oversteer condition. DRI cannot cite this condition as an example of why oversteer is good and then use it to say oversteer is bad.
 - Steady-state tests are good for overall vehicle characteristics but there are dynamic properties of a vehicle that will not be captured. A transient test like the J-Turn is required to capture those dynamic characteristics.
- CPSC staff made the following comments:
 - There is continuing disagreement between ROHVA and CPSC staff regarding the importance of steering characteristic (oversteer/understeer).
 - Staff is encouraged that ROHVA is looking at dynamic testing on asphalt.
 - Staff is putting data together on J-Turn tests that were performed on several model ROVs. As soon as it is ready, the information will be made public.

The ROHVA representatives summarized that the development of the constant steer dynamic test was in response to CPSC staff's concerns with low speed quarter rollovers of ROVs. ROHVA is committed to studying the issues and would like to return in 60 days for a progress report and continued dialogue with CPSC staff.

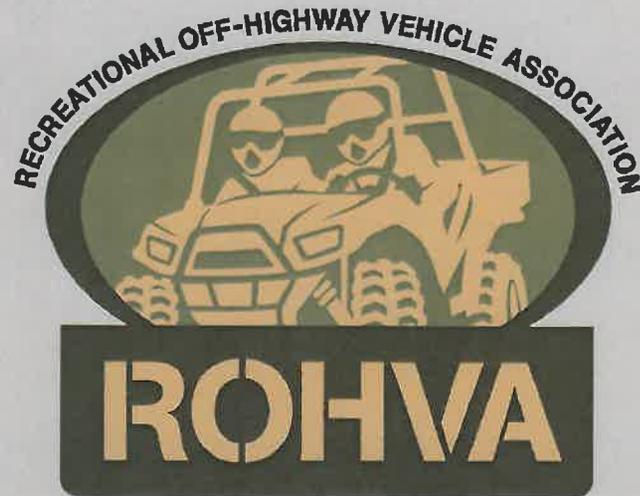
MEETING ATTENDANCE RECORD
ROHVA / CPSC Staff – October 7, 2010

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**ROHVA Update:
Standards Development and Safety Programs**

Presented to
U.S. Consumer Product Safety Commission
Technical Staff
October 7, 2010

ROHVA's Comprehensive Safety Action Plan



RECREATIONAL OFF-HIGHWAY
VEHICLE ASSOCIATION

Vehicle Voluntary Standard

1. **Mandatory Static *and* Dynamic Stability Standards**
2. **Mandatory Occupant Retention Performance Standards**
3. **Mandatory Restraint Warning System**
4. **Expanded Vehicle Class to Meet CPSC – ANPR Max Speed \geq 30 MPH**

Occupant Behavior

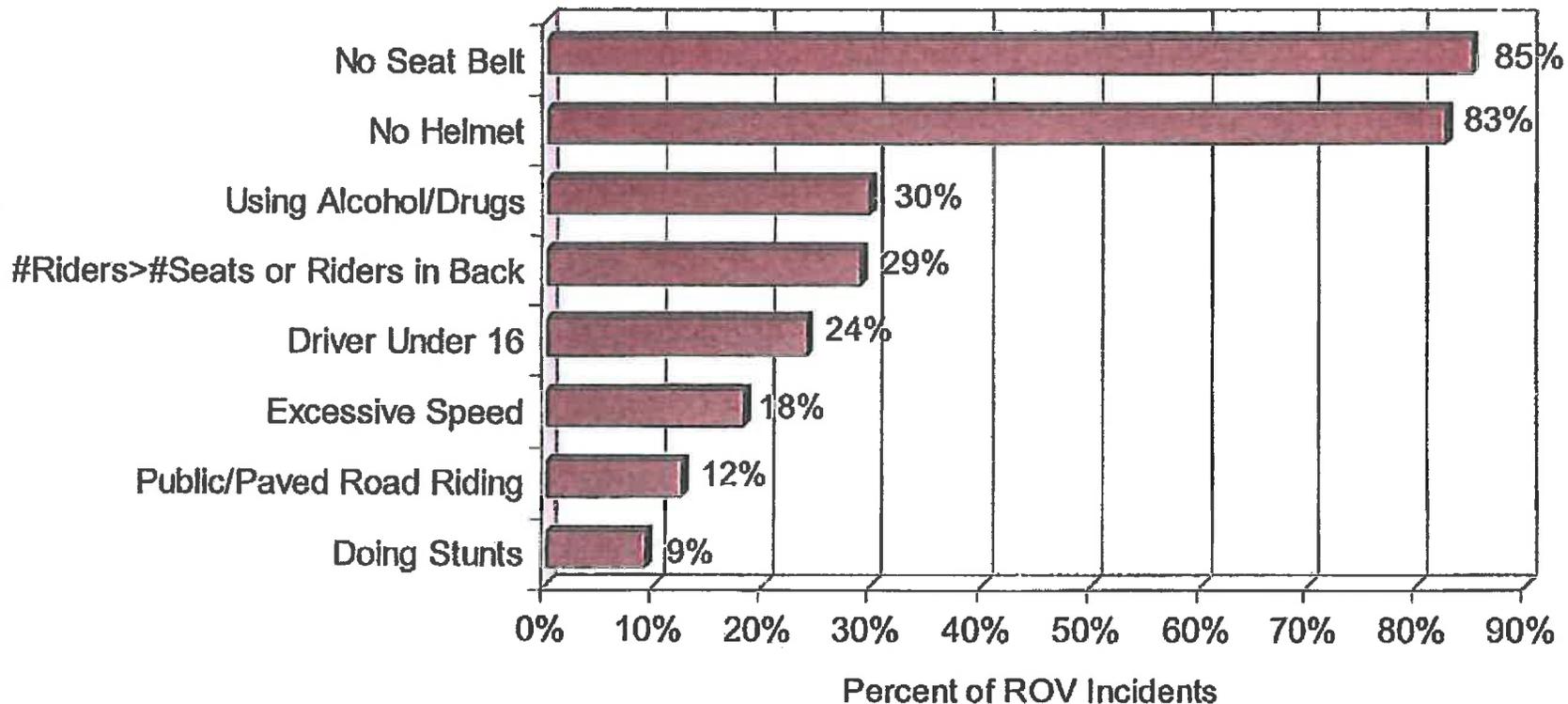
1. **Mandatory Helmet and Seatbelt Use**
2. **Standardized Warning Labels**
3. **Free E-Course Training Emphasizing:**
 - **Helmet and Seatbelt Use**
 - **Warned Against Behaviors & Driver Error**
4. **Hands-On Training**

Continuing Progress Based on Facts & Data

Review of Top Incident* Factors



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ROHVA Focus: Fact & Data Based Standards Development

Education and Training



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ROHVA – 2010 and beyond

- **ROV DriverCourse** consisting of:
 - ROV E-Course – www.rohva.org
 - ROV Hands-On course now under development
- **ROV E-Course: Over 1,100 enrolled since July.**
- **ROV Hands-On course**
 - Leveraging association expertise
 - Hired training consultants
 - Initial track layouts & driving
 - Beginning training development



Training To Address Top Factors In IDI Analysis

Warning Labels



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ROHVA – 2010 and beyond

- ROHVA members working on standardized warning label content
- Develop uniform safety messages
- Will be included in updated standard



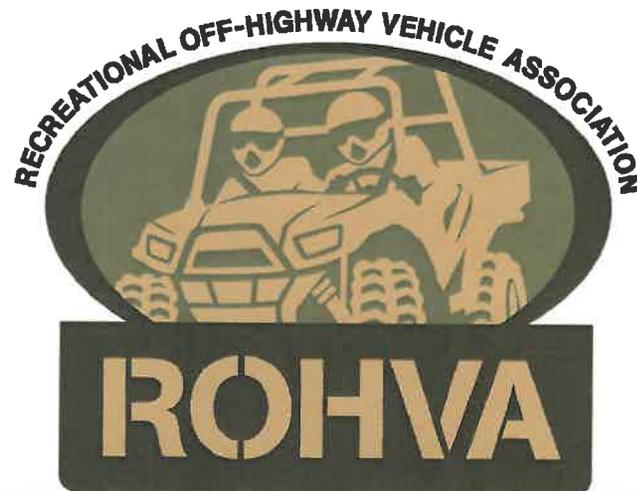
Continuing Progress to Address Top IDI Analysis Factors

Jan Rintamaki



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**Chairman, ROHVA Board of Directors
Polaris Industries Inc.**



Technical Update



- **IDI analysis → Occupant Retention Systems (ORS)**
 - Voluntary actions by the industry
 - Zone based elements of ORS
 - Discussion topics: Active vs. passive restraints
- **Dynamic stability update**
 - Low speed rollovers/IDI analysis
 - Lateral acceleration is needed to generate low speed rollovers
 - Focused on testing that repeatedly, accurately generates lateral acceleration

ROHVA Comprehensive Safety Plan

Occupant Retention & Protection System



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- **Occupant Retention & Protection System includes:**
 - * ROPS
 - * Seat Belts
 - * Hand holds
 - * Foot / Leg Retention
 - * Hip / Shoulder / Arm Retention
 - * Seats / Headrests
- **ROHVA Members: Already mandating helmet use and providing side retention on All Model Year 2011 ROVs**



- **All ROV standards should recommend mandatory helmet use**

ROHVA Members: Occupant Retention & Protection System

Occupant Retention System (ORS)



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ROHVA Proposed Occupant Retention System:

(ANSI/ROHVA 1-2010)

- ROPS, 3-pt seat belt, helmet

(From 7-20-10): Zone based requirements

- Passive & active systems
- Feet / Legs – minimal mobility required
- Shoulder / Hip – minimal mobility required
- Hand / Arm – steering wheel input required
- Head – needs unrestricted visibility w/ helmet

For Discussion:

- Active vs. Passive systems
- Unintended consequences of overly passive or overly active systems



ROHVA Action: Mandatory Occupant Retention System

Occupant Retention Considerations



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- **Visibility**
 - Full side barriers restrict vision
- **Mobility**
 - Systems must permit hand-over-hand steering and visual scanning
 - Systems must permit easy, uncomplicated ingress/egress
- **Usage**
 - Complex systems discourage use and may result in removal
 - Side barriers should not create pinch points and other hazards
- **Environmental**
 - Systems should function in off-highway environment
 - Systems should not discourage the use of full protective gear

Finding Acceptable Balance

Dynamic Stability Update



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- **Dynamic stability update**
 - Low speed rollovers/IDI analysis
 - Lateral acceleration is needed to generate low speed rollovers
 - Focused on testing that repeatedly, accurately generates lateral acceleration
- **Dynamic testing evaluations and development**
 - J-266 & J-Turn (historically automotive based tests)
 - ROV Rollover Resistance (new, developed by ROHVA/DRI)
 - Still addressing test surface issues, moving toward off-highway environments

Comparison, Test Protocols, Data, Conclusions

Dynamic Testing Development



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- **Goal: Evaluate rollover resistance in off-highway environment**
- **Action: Retained DRI to design a simple, repeatable, reproducible test**
 - **Analyze prior DRI work on representative off-highway terrain to establish potential benchmark(s)**
 - **Consideration of other dynamic tests**
 - **Develop a new dynamic test concept**
 - **Conduct preliminary testing**
 - **Review preliminary test results**

New Dynamic Test Concept



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- **Description:**
 - Small radius, fixed steer input, limit condition
- **Protocol:**
 - Lock steering wheel at small radius steering angle
 - Slowly accelerate until vehicle limit condition is reached
- **Pass / Fail Criteria:**
 - No 2 wheel lift below a specified lateral acceleration; OR
 - Limit steady state condition is reached with no 2 wheel lift



New Test Developed By ROHVA/DRI

Dynamic Research, Inc.

Commissioned by ROHVA



John Lenkeit

Technical Director, Dynamic Research, Inc.
Chairman, SAE Motorcycle Committee

Peter Broen

Principal Engineer, Dynamic Research, Inc.

Dynamic Research, Inc.

ROV ROLLOVER RESISTANCE TESTING CONSIDERATIONS

- ROVs are designed to be operated off-highway and should be tested on an off-highway surface
- A suitable, repeatable, reproducible off-highway surface does not exist
- To determine benchmark for lateral acceleration limits, useful to examine off-highway terrain coefficient of friction
 - 0.60 g is not achievable on average off-highway terrain; represents 60% of body weight force on the human body
 - Off-highway operator senses vehicle nearing limit before 0.40 g
- A Roll Resistance Margin can be derived from a formula using those benchmarks
- Also, useful to examine guidelines for highway design
 - AASHTO “comfort” zone = 0.30 g at 20 mph; lower at higher speeds
 - On-highway operator senses extreme feedback at 0.50 g (both physical and vehicle, e.g. tire noise)

OFF-HIGHWAY TEST SURFACE CONSIDERATIONS

- Repeatable, test to test and over time, long-term stability
- Reproducible in various regions worldwide
- Reasonable costs to install and to maintain
- Not moisture sensitive
- Peak μ within the range of “most common” to “maximum” (i.e., worst case) values measured at actual Off-Highway areas
- Typical shape of μ -slip curve for off-highway soils (i.e., no sharp peak, ideally increasing with higher slip)
- Not requiring “grooming” of the surface between or during tests (i.e., on a deformable surface the circular nature of path can result in in berms and cross-berm operation)
- “Tunable” (i.e., friction level can be varied during surface development, in order to meet needs)

OFF-HIGHWAY TEST SURFACE CONSIDERATIONS

Methods used to collect ATV tire/soil side force coefficient data for 20 ATV ride sites in May 1990 report

- Used towed rolling-tire/soil force measurement system
- Measured tire lateral force for:
 - 1980's lugged ATV-type tire
 - Range of vertical loads
 - Range of lateral slip angles
 - At about 20 ATV ride areas across US
- Lateral coefficient of friction at 300 lb and 15 degrees slip angle is relevant to ROVs

OFF-HIGHWAY TEST SURFACE CONSIDERATIONS

Distribution of ATV tire/soil side force friction coefficient values for about 20 US ride areas

- Mean lateral side force coefficient: **0.55**
- Range of lateral side force coefficient is relatively narrow
 - 18/20 soils were between 0.45 and 0.65
- These data do not support use of a high side force coefficient asphalt surface, except as “a readily available extreme that lies far beyond the tire/soil data”

OFF-HIGHWAY TEST SURFACE CONSIDERATIONS

- It is possible to measure the “tire/soil side force coefficient” for off-highway soils, using an example tire
- The “tire/soil side force coefficient” is representative of the ***maximum lateral acceleration*** (in g units) achievable on a given soil
- Therefore, for a given soil, one can compare ***maximum lateral acceleration at 2-wheel lift*** to “tire/soil side force coefficient”
 - This can provide an index of “roll resistance margin,” i.e.:

$$\text{RollResistanceMargin} = \left(\frac{A_{y_{\text{ground, 2wheel lift}}}}{\text{tire / soil side force coefficient}} - 1 \right) \times 100\%$$

OFF-HIGHWAY TEST SURFACE CONSIDERATIONS

These data do support a criterion for “minimum lateral acceleration at 2 wheel lift” of say 0.60 g, i.e., for a mean lateral side force coefficient of 0.55, this would provide:

$$\text{RollResistanceMargin} = \left(\frac{0.60}{0.55} - 1 \right) \times 100\% = 9\%$$

- Substantially increasing the Roll Resistance Margin beyond 9% (i.e., substantially increasing the criterion for “minimum lateral acceleration at two wheel lift” above 0.60 g):
 - For a given vehicle configuration, would decrease off-highway mobility
- While operating a given ROV, its Roll Resistance Margin:
 - Can increase or decrease, depending on the local soil
 - Conceivably, can become negative on sufficiently high side force coefficient soil
 - If negative, “2 wheel lift” is theoretically possible, but:
 - Depends on driver’s aggressiveness
 - Turning at greater than 0.60 g or slope greater than 30 degrees is very aggressive

OFF-HIGHWAY TEST SURFACE CONSIDERATIONS

- Therefore, a criterion for “minimum lateral acceleration at two wheel lift” in the region of 0.60 g:
 - Provides a Roll Resistance Margin on typical soils of 9%
 - Provides an appropriate balance between Roll Resistance Margin and off-highway mobility

TEST DEVELOPMENT – OBJECTIVES AND REQUIREMENTS

To identify, develop and conduct lateral roll resistance tests for ROVs which are:

- Dynamic (i.e. involve a moving vehicle)
- Repeatable within some tolerance
- Reproducible within some tolerance

and

- Not unduly complicated

TEST TYPES CONSIDERED

SAE J266

- Measures “steering characteristics” (i.e., understeer gradient)
- Does not measure 2 wheel lift or other types of limits
- “Control limit” and “stability limit” mentioned in J266 are purely subjective in nature, and, as they stand, are not clearly defined, objective, repeatable or reproducible
- Potential criteria for “steering characteristics” have unclear relation to roll stability
- Results show substantial scatter/driver dependency

J-Turn

- Many variations of J-Turn exist (e.g., ISO 7401)
- Fundamentally involves a “transient” steer input
- Challenge is how to apply a repeatable transient steer input, along with a repeatable level of speed control
- If “speed control” is that resulting from “closed throttle,” then:
 - Results are highly sensitive to exact timing of closed throttle, relative to steer input, plus drive train variability

Fixed-steer-gradually-increasing-speed test

- Relatively high levels of repeatability and reproducibility
- On asphalt surface, results in 2 wheel lift for some ROVs

WORKING DEFINITIONS

Limit condition

Condition for which further increases in throttle input do not increase the vehicle speed including:

- 2 wheel lift (2 inches at both inside wheels)
- 1 wheel spin/lift
- 2 wheel spin/spiral-in
- Spiral-out

DRAFT TEXT FOR FIXED STEER TEST AND IDEAS FOR FORM OF POTENTIAL CRITERIA

Rationale:

- Goal is to evaluate ROV rollover resistance based on propensity for “2 wheel lift” at lateral accelerations that can be reached on off-highway surfaces
- Other types of limit (e.g., 1 wheel spin/lift, 2 wheel spin/spiral-in) do not evidence propensity for rollover

TEST PROCEDURES

Test Summary

- 5 example vehicles
 - Arctic Cat Prowler 700 XTX (2010)
 - Can Am Commander (2011)
 - Polaris Ranger RZR 800 (2011)
 - Polaris Ranger RZR S 800 (2011)
 - Polaris Ranger XP 800 (2011)
- 2 loading conditions
 - “Light”: driver and test equipment only
 - “Nominal”: driver and test equipment + ballast required to bring total load to equivalent of 2 x 215 lb occupants

TEST PROCEDURES

Test Summary

- 2 steering conditions (both based on 20 ft radius to center line of vehicle)
 - “Steering Wheel Angle Based on Low Speed Turn Radius” : Steering wheel angle required to track circle at low speed
 - “Ackermann Steering Wheel Angle”: Calculated steering wheel angle based on wheelbase, desired turn radius and measured relationship between steering angles of front wheels and steering wheel angle
- Left and right turning direction
- Most “open” driveline configuration
- Minimum of 5 repeats
- Procedure: With steering wheel angle mechanically secured, slowly increase speed from minimum until a limit is reached

TEST PROCEDURES

- Test surface used

Surface	Asphalt
Friction coefficient	0.95 as measured in accordance with ASTM E 1337
Slope	< 1%

EXAMPLE FIXED STEER TEST PHOTOS Two wheel spin/spiral-in limit



EXAMPLE FIXED STEER TEST PHOTOS 1 wheel spin/lift limit



PRELIMINARY RESEARCH FOR DISCUSSION PURPOSES ONLY

EXAMPLE FIXED STEER TEST PHOTOS

Two wheel lift limit



EXAMPLE FIXED STEER TEST PHOTOS

Two wheel lift limit



EXAMPLE FIXED STEER TEST PHOTOS Two wheel lift limit



EXAMPLE FIXED STEER TEST PHOTOS

Two wheel lift limit



EXAMPLE FIXED STEER TEST PHOTOS

Two wheel lift limit



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Two wheel lift limit



EXAMPLE FIXED STEER TEST PHOTOS Two wheel lift limit



EXAMPLE FIXED STEER TEST PHOTOS Two wheel lift limit



DATA REDUCTION

DATA REDUCTION STEPS

- Ensure data integrity
- Digital Smoothing Filter
 - 12 pole phaseless Butterworth filter with cutoff frequency of 6 Hz
 - Used for US/FMVSS 126 (ESC)
- Generate and graph time history of the ground plane component of the body-fixed lateral acceleration ($A_{y_{ground}}$)
- Correct for roll angle
- Overlay events on $A_{y_{ground}}$ time history plot
- 2 wheel lift
- Maximum speed
- Confirm speed increase rate prior to $A_{y_{ground}}$ peak does not exceed limits
- Determine maximum $A_{y_{ground}}$ value that occurs before limit is reached

OBSERVATIONS, FIXED STEER TESTS

Mean peak lateral acceleration ($A_{y_{ground}}$)

- Left vs right turns
 - Left turns had greater $A_{y_{ground}}$
- Vehicle-to-vehicle differences for 2 wheel lift limit
 - Vehicle 2: 0.64 – 0.67 average L + R
 - Vehicle 1: 0.69 – 0.74 right turns only
 - Vehicle 4: 0.77 – 0.80 average L + R
- Vehicle 3 and Vehicle 5 achieved limit conditions without 2 wheel lift
- Light vs Nominal load
 - Similar, no consistent difference
- Low speed” vs “Ackermann” steer input
 - Similar, no consistent difference

OBSERVATIONS, FIXED STEER TESTS

- Variability, peak lateral acceleration (i.e., range)
 - Left vs right turn: Similar, no consistent difference
 - Within each vehicle: 36/40 conditions had relatively small variability (i.e., range less than $\pm 5\%$)
 - Across “Type of Limit”
Runs with 2 Wheel Lift Limit had less range in measured $A_{y_{ground}}$ (i.e. typically 4% versus 7% for 2W Spin/Spiral-In and 8% for 1 Wheel Spin)
 - “Low speed radius” vs “Ackermann” steer input: Similar, no consistent difference
 - Average range/mean (%) 6% (i.e., $\pm 3\%$)
- Variability, nature of limit: 36/40 conditions (vehicle, direction, loading, and steer angle) had consistent nature of limit

RECOMMENDATIONS REGARDING STEER INPUT

- Suggest to use Ackermann method, because:
 - For those vehicles which have locked rear differential or solid axle, using the alternative method (i.e., “steer angle required to follow a 20 ft radius at very low speed”) on a high friction surface results in:
 - Greater differential (yaw resisting) torque at the rear axle(s)
 - Greater steer torque and angle required to overcome differential torque
 - As speed is increased in the constant steer angle test, the inside rear tire begins to unload allowing slip, reducing differential torque and yaw resistance, and therefore
 - Vehicle turns more sharply,
 - In some cases, resulting in a very small radius “2 wheel spin/spiral-in”
 - Ackermann method provides for a 20 ft path radius (vehicle centerline) at zero lateral tire slip.

COMMENTS ON J-TURN TEST FOR DYNAMIC ROLL RESISTANCE EVALUATION

- “J-Turn” test is a generic term used for a maneuver characterized by straight-line initial condition ending in a circular or spiral curve; i.e., a “J” shape of vehicle path as viewed from above
- The change from straight-line to turning involves a “transient” maneuver after which the vehicle may reach a steady state condition
- Usefulness of J-Turn for dynamic roll resistance evaluation depends on:
 - How speed is controlled, and how accurately speed is controlled during entire J-Turn
 - Difficulty of maintaining constant speed from straight line through near-limit turning conditions
 - If speed is not constant, interaction between two transients (steering and speed) and drive train response degrades repeatability
 - Which portion of J-Turn is of interest
 - the transient
 - the steady-state
 - both the transient and the steady-state

PRELIMINARY RESEARCH FOR DISCUSSION PURPOSES ONLY

COMMENTS ON J-TURN TEST FOR DYNAMIC ROLL RESISTANCE EVALUATION

- Motivation for proposing a J-Turn test
 - Steady state tests at higher speeds
 - Alternate method for low speed steady state test
 - Successive test runs at incrementally increasing speed
 - Evaluate transient response - Limit to lower - mid speed regime

COMMENTS ON J-TURN TEST FOR DYNAMIC ROLL RESISTANCE EVALUATION

Steady state tests at higher speeds

- Advantages:
 - Smaller test area may be sufficient
- Disadvantages:
 - Higher speeds (30+ mph) on pavement introduces undesirable dynamics that are not typically encountered in actual use in an off-highway environment
 - Higher speed operation on pavement is product misuse and may present risks to the test operator
 - Difficult to maintain constant speed
- Conclusion
 - Not recommended; higher speeds tests on pavement are inappropriate and may present risk to the test operator

COMMENTS ON J-TURN TEST FOR DYNAMIC ROLL RESISTANCE EVALUATION

Alternate method for low speed steady state test

- Advantages:
 - Tire cooling between runs
 - Possibly easier to approach limit condition without exceeding it
- Disadvantages (as compared to fixed steer slowly increasing speed):
 - Added complexity for testing and analysis
 - More runs needed
 - Difficult to maintain constant speed
- Conclusion
 - Not recommended; added complexity with no value added

COMMENTS ON J-TURN TEST FOR DYNAMIC ROLL RESISTANCE EVALUATION

Evaluate transient response (lower to mid-speed regime)

- Advantages:
 - Complementary to steady state analysis
- Disadvantages:
 - Steering robot would be needed to evaluate and develop procedures and for testing
 - Difficult to maintain constant speed during transient maneuver
 - Order of magnitude change in complexity and cost of testing
 - Repeatability would be difficult to achieve
- Conclusion
 - Not recommended

COMMENTS ON SAE J266 TEST FOR DYNAMIC ROLL RESISTANCE EVALUATION

- Disadvantages
 - Measures “steering characteristics” (i.e., understeer gradient)
 - Does not measure 2 wheel lift or other types of limits
 - “Control limit” and “stability limit” mentioned in J266 are purely subjective in nature, and, as they stand, are not clearly defined, objective, repeatable or reproducible
 - Potential criteria for “steering characteristics” have unclear relation to roll stability
 - Results show substantial scatter/driver dependency
- Conclusion
 - Not recommended

ADVANTAGES OF ROLL RESISTANCE TEST

- Developed for ROVs
- Directly addresses low speed roll over
- Suitable for roll resistance pass/fail
- Reduces adverse effects of asphalt surfaces
- Simple & repeatable
- Off-highway potential
- Simple input with low complexity
- Eliminates driver variation or need for robots
- Insensitive to transmission performance

Conclusion and Next Steps

- **Address the issues raised in the ANPR in updated ANSI/ROHVA standard**
- **Address additional safety related issues**
- **Committed to continue studying the issues**
- **Return within 60 days for a progress report and continued dialogue**

CPSC Feedback for Continued Joint Standards Development