



# SURFACE VEHICLE INFORMATION REPORT

J2588™

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## Remote Steering Control Systems

### RATIONALE

This document is being updated to revise the total amount of cycles required during the service life test. The cycles required reflect the same amount of cycles that are required by other SAE documents concerning Adaptive Primary Driving Controls.

#### 1. SCOPE

This SAE Information Report establishes a uniform procedure for assuring the manufactured quality, installed utility, and performance of automotive remote steering controls other than those provided by the vehicle manufacturer (OEM). These products are intended to provide driving capability to persons with physical disabilities. The adaptive modifications seek to compensate for lost or reduced function in the extremities of the driver with a disability. Remote steering controls are designed to provide a steering input device alternative to the OEM steering wheel that either reduces the required input force, changes the required range of motion or changes the location of the steering control, or any combination of the above. These controls supplement by power, other than by the driver's own muscular efforts, the force output of the driver with a disability. Because this is an Information Report, the numerical values for performance measurements presented in this report and in the accompanying Test Procedure, while based upon the best knowledge available at the time, have not been validated by a testing of the Test Procedure.

##### 1.1 Inclusions

This document is specifically concerned with mechanical and electrical products intended by the manufacturer to meet the following criteria.

1.1.1 Is operated by a vehicle driver with a physical disability.

1.1.2 Substitutes for the use of the OEM steering wheel.

1.1.3 Output of the remote steering device is applied to the OEM steering system in order to change the force or range of motion or ability to reach the steering control required of the driver with a disability.

##### 1.2 Exclusions

This document specifically excludes any automotive adaptive product which:

1.2.1 Is applied to vehicles without powered steering unless it is specifically designed for that application and clearly states that in its product literature.

1.2.2 Modifies the OEM steering effort control system as identified in SAE J2672 (Reduced Effort Steering document).

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1.2.3 Is considered to be Group B Control or Secondary Control.

1.2.4 Is intended as a special control for driver evaluation, training, or research.

### 1.3 Purpose

The purpose of this document is to provide criteria to evaluate remote steering control system design, manufacture, installation, operation, maintenance, and performance. Methods to measure those criteria are included in the Recommended Test Procedures (RTP) attached as an Appendix to this Information Report.

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), [www.sae.org](http://www.sae.org).

|             |                                                                                                                        |
|-------------|------------------------------------------------------------------------------------------------------------------------|
| SAE J429    | Mechanical and Material Requirements for Externally Threaded Fasteners                                                 |
| SAE J1113   | Electromagnetic Susceptibility Measurement Procedures for Vehicle Components (Except Aircraft)                         |
| SAE J1159   | Preparation of SAE Technical Reports - Surface Vehicles and Machines                                                   |
| SAE J1199   | Mechanical and Material Requirements for Metric Externally Threaded Steel Fasteners                                    |
| SAE J1213/2 | Glossary of Reliability Terminology Associated with Automotive Electronics                                             |
| SAE J1725   | Structural Modification for Personally Licensed Vehicles to Meet the Transportation Needs of Persons with Disabilities |
| SAE J1739   | Potential Failure Mode and Effects Analysis (FMEA), Including Design FMEA, Supplemental FMEA-MSR, and Process FMEA     |
| SAE J1903   | Mechanical and Hybrid Automotive Adaptive Driver Controls                                                              |
| SAE J2094   | Vehicle and Control Modifications for Drivers with Physical Disabilities Terminology                                   |

### 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

#### 2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), [www.sae.org](http://www.sae.org).

|           |                                                            |
|-----------|------------------------------------------------------------|
| SAE J2603 | Recommended Practice for Powered Gas Brake Control Systems |
|-----------|------------------------------------------------------------|

### 2.2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9500, [www.astm.org](http://www.astm.org).

ASTM B117 Method of Salt Spray (Fog) Testing

### 2.2.3 AWS Publications

Available from American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672, Tel: 1-800-443-9353 or 305-443-9353, [www.aws.org](http://www.aws.org).

AWS D1.1-72 Structural Welding Code

AWS D10.7-60 For Gas-Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe

### 2.2.4 NHTSA Publications

Available from National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE, West Building, Washington, DC 20590, Tel: 1-888-327-4236, [www.nhtsa.gov](http://www.nhtsa.gov).

FMVSS No. 101 Controls and Displays

FMVSS No. 108 Lamps, Reflective Devices, and Associated Equipment

FMVSS No. 201 Occupant Protection in Interior Impact

FMVSS No. 203 Impact Protection for the Driver from the Steering Control System

FMVSS No. 204 Steering Control Rearward Displacement

FMVSS No. 208 Occupant Crash Protection

FMVSS No. 302 Flammability of Interior Materials

49 CFR Part 595, subpart C "Exemptions from the Make Inoperative Prohibition; Final Rule"

### 2.2.5 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

MIL-STD-1472 Department of Defense Design Control Criteria Standard: Human Engineering.

## 3. DEFINITIONS

For the purpose of this SAE Information Report, the following definitions apply.

### 3.1 COMMON HAND TOOL

Handheld device, available for purchase in consumer stores, that is used to perform common mechanical and electrical repairs.

### 3.2 CONTROL BOX

The control box is the component of the remote steering control system which is mounted in the driver's space and on which the control input mechanism is located. The function of the control box is to translate the motion of the control-input mechanism into some type of control information to be sent to the remainder of the system.

### 3.3 CONTROL CLASSIFICATION

Document groupings based on the potential consequences of product failure. The groups are listed in order of importance (refer to SAE J2094).

#### 3.3.1 Primary Controls

##### 3.3.1.1 Group A

Those controls operated by the driver which directly affect the direction and rate of the moving vehicle, including the steering, brake, and gas controls. All sections of this document are applicable to Group A primary controls.

##### 3.3.1.2 Group B

Those controls operated by the driver which are essential to the coordinated and safe operation of the vehicle in traffic situations. This includes ignition/starter switch, gear selector, parking brake, turn indicator lever, hazard flasher, horn, wiper/washer, defroster control, mirror, and headlight dimmer. No sections of this document apply to Group B primary controls.

#### 3.3.2 Secondary Controls

Those controls not related to vehicle movement, operable by the driver or passenger, that regulate the environment of the vehicle, including heater/air conditioner, window regulator, vent, sun visor, seat positioner, radio, door lock, cigarette lighter, courtesy light, and any controls associated with wheelchair lifts, door openers, wheelchair restraints, etc. No sections of this document apply to secondary controls.

### 3.4 CONTROL INPUT MECHANISM

The point of contact on the adaptive product where input motions of the operator are applied.

### 3.5 CONTROL LOGIC COMPONENTS

Components of a control responsible for the decision-making process that translates a given input into a specific and repeatable output. These components include, but are not limited to, the control-input signal, the control signal processing system, and the control output signal.

### 3.6 DRIVER'S SPACE

The volume inside the vehicle occupied by the vehicle operator and containing all primary and secondary controls (refer to SAE J1903).

### 3.7 ELECTROMAGNETIC INTERFERENCE (EMI)

A condition in which sources of energy or electromagnetic activity within a system interfere with the function of the system and subsystems or interfere with and/or are affected by other systems.

### 3.8 FEEDBACK

The recycling of a portion of the output of a system to the input. Systems employing feedback for the purpose of bringing the output quantity closer to a desired value are called feedback control systems.

### 3.9 LAG

The delay between input and output inherent in any system, which usually becomes larger as input changes become more frequent.

### 3.10 LOCK-TO-LOCK STEERING

The total rotational travel of the OEM vehicle steering input shaft from one steering end-stop to the other.

### 3.11 DRIVER WITHOUT A DISABILITY

The driver for whom the vehicle was originally designed by its OEM.

### 3.12 OEM

An abbreviation for Original Equipment Manufacturer. This refers to the vehicle, and its systems, as they are designed and produced by the automobile manufacturer (refer to SAE J1725).

### 3.13 PHYSICAL DISABILITY

The absence or reduction of a neuromuscular or orthopedic function of the human body.

### 3.14 POWERED

Those systems which are operated by an energy source other than manual power.

### 3.15 REMOTE STEERING CONTROL

A device which changes the location of the steering input and uses power from an energy source of the vehicle to supplement the force and motions made by the driver to control the steering of a vehicle.

### 3.16 PRODUCT LITERATURE

Information about a manufacturer's product which, while it may or may not be distributed for advertising purposes, should be available to consumers upon request.

### 3.17 RADIO-FREQUENCY INTERFERENCE (RFI)

A condition in which sources of energy or electromagnetic activity outside of a system interfere with the function of the system and subsystems.

### 3.18 RANGE OF MOTION

An imaginary volume of space whose outer shape and dimensions are described by the limits of movement of a person or a movable portion of that person's body.

### 3.19 REDUNDANCY

The existence of more than one means of accomplishing a given function (refer to SAE J1213/2).

### 3.20 REDUNDANT POWER SUPPLY (BACKUP POWER SUPPLY, SECONDARY POWER SUPPLY, AUXILIARY POWER SUPPLY, ETC.)

A power source isolated from the main vehicle power supply capable of supplying backup power to a control in the event of main power supply degradation or failure.

### 3.21 RESPONSE TIME

The elapsed time between initiation of a step input to the control input mechanism until the time when the output reaches 63% of the output associated with the selected level of steady-state input.

### 3.22 SERVO

A power device which amplifies control forces and automatically corrects the output in proportion to input (refer to SAE J2094).

### 3.23 SHALL

The term to be used whenever the criteria for conformance with the specific recommendations requires that there be no deviation (refer to SAE J1159).

NOTE: Because this is an Information Report which makes recommendations, but is not a standard, the use of the word shall has been replaced by should elsewhere in the report.

### 3.24 SHOULD

The term to be used whenever noncompliance with the specific recommendation is permissible (refer to SAE J1159).

### 3.25 STEERING END-STOP

The mechanical limit of rotation of the OEM steering shaft in either direction as determined by the OEM power steering pump bypass function.

### 3.26 STEP INPUT

An input into a control system in which the input is made at one time rather than as a gradual increase or an increase following a specific mathematical function.

### 3.27 UNIDIRECTIONAL

Revolving, functioning, moving, or responsive in a single direction (refer to SAE J1903).

### 3.28 VISIBLE DEFORMATION

A change in alignment, position, or shape that is apparent to a careful observer (refer to SAE J1903).

## 4. PERFORMANCE REQUIREMENTS AND MANUFACTURING QUALITY

### 4.1 Remote Steering Control Performance

The remote steering control should not degrade the performance attainable with the OEM unmodified steering system except as noted in this Information Report. Failure of the remote steering control system to attain the performance characteristics attainable with the (OEM) power steering system using input forces on the control input mechanism, specified by the control manufacturer, should be unacceptable (see 4.1.6.1 and 4.1.6.2).

#### 4.1.1 Force and Travel Input

The control manufacturer should specify the minimum input force required to operate the control input mechanism, the location on the control input mechanism where the force is to be applied, and the corresponding travel of the control input mechanism in relation to that point by incorporating them into their user manual or product literature. These force and travel input specifications are to be the maximum force and travel of the steering control system and are intended to provide information to users about the system characteristics. The manufacturer should also specify the steering control output, which should result from those inputs (see A.2.6 and A.4.1).

#### 4.1.2 Torque Output

The output of the remote steering control system should be capable of steering the vehicle at any speed for 5 minutes with the OEM power steering failed in the vehicle specified by the manufacturer as suitable for installation of the remote steering control system (see A.4.1.2).

*Rationale:* These requirements are designed to ensure that the remote steering control system does not degrade the steering performance of the OEM steering system, regardless of any changes made.

#### 4.1.3 Control Predictability

The output of the remote steering control system as applied to the OEM components should bear a repeatable relationship to the inputs.

##### 4.1.3.1 Repeatability

A given input to the remote steering control should cause a repeatable corresponding output to the OEM system (see A.4.2.5).

*Rationale:* This is to ensure that the control system does not present any variables in operation, causing the operator to have to search for the correct position of the control mechanism for the desired response each time the control is operated.

4.1.3.2 The remote steering control system initial response time for steering should not exceed 0.1 second (see A.4.2.6).

4.1.3.3 Lag or delay in response of the control output to driver input is inherent in any powered control system; however, lag should not be sufficient to degrade performance in an offset lane test (see A.4.1.6.1).

4.1.3.4 Lag or delay in response of the control output to driver input is inherent in any powered control system; however, lag should not be sufficient to degrade performance in a slalom test (see A.4.1.8.1).

*Rationale:* This is to ensure that the control system does not cause the operator to introduce oscillations searching for the correct response from the control mechanism having made the needed input, adding more when the system does not respond properly then reversing the control when the system over-responds.

#### 4.2 Mandatory Automatic Redundant Power Supply

If the primary system power fails, or degrades to the point that adequate steering control is lost, a Redundant Power Supply should be available automatically and without requiring any control action by the driver.

4.2.1 A failure analysis of the primary power supply for the remote steering control system should be conducted to determine the threshold of function for the primary power supply at which the automatic redundant power supply should be activated (see A.2.6).

4.2.2 The manufacturer should specify a means to identify the redundant power supply and a means for disconnecting and reducing the remote steering control system primary power supply to the threshold identified in the failure analysis in such a way that the remote steering control system remains functional (see A.2.6).

4.2.3 The automatic redundant power supply should be available within 0.5 second of the loss of primary system power to the threshold determined in the failure analysis of 4.2.1 above, without any additional control motions by the driver (see A.4.1.3.1).

4.2.4 The automatic redundant power supply should be sufficient to maintain normal operation of the steering control for at least 5 minutes of operation (see A.4.1.3.2).

*Rationale:* All remote steering controls are dependent upon some energy source. In the event of loss or degradation of the primary energy source, the automatic redundant power supply would be available to supplement power to the control system. Also, if there is a problem with the primary control power source, the driver may be far too preoccupied to enable the backup power system manually. The automatic activation will provide for continuing remote steering control service for a period of time sufficient to drive the vehicle to safety and service the primary power source.

### 4.3 Control Logic Redundancy

All remote steering control systems should incorporate redundancy of essential control system logic components.

- 4.3.1 A failure analysis using SAE J1739 or equivalent should be conducted to support the selection of the redundant control system logic components as well as the function of the redundant components (see A.2.6).
- 4.3.2 The manufacturer should specify a method of disconnecting the components of the remote steering primary logic control system in such a way that the redundant portions of the remote steering logic control system remain functional in order for the automatic activation to be tested.
- 4.3.3 The redundant components for the control logic should be designed to assure that failure of the primary system components will not cause a failure of the redundant system components and should be automatically activated (see A.4.1.4).
- 4.3.4 A diagram should be completed to identify the relationships of the redundant control system logic components to the remainder of the system (see A.2.6).

*Rationale:* The purpose of the remote steering control system logic redundancy requirement is to provide the vehicle with protection from failure of the remote steering control system. The system should maintain steering capability in the event of critical primary control logic component failure.

### 4.4 Service Life

The remote steering control system, when installed and maintained according to the manufacturer's instructions, should perform for 250000 cycles (a cycle defined as rotation of the OEM steering shaft from one steering end-stop to the other and back again) (see A.4.2.1).

*Rationale:* The remote steering system should be designed last for the expected lifetime of the OEM steering components. While 250000 cycles will not necessarily represent the number of cycles endured during the lifetime of the steering system, it should demonstrate the long-term durability of the system and is comparable to the service life test that OEM steering components must meet.

### 4.5 Service Overload

The control input mechanism should not deform under loads which could be expected in anticipated driving conditions (see A.4.2.2).

*Rationale:* Occasionally, the remote steering control input mechanism will be subjected to momentary overloads induced by the driver (panic stops, evasive maneuvers, sudden changes of direction, loss of power steering, etc.) and by the vehicle transmitted back to the controls (curb impacts, road irregularities, and blowouts). While these events may not be considered normal, they can be anticipated to occur during the service life of the control. The remote steering control system is expected to withstand such events with no resulting degradation of strength or performance.

### 4.6 Control Box Connections

All components (wires, hoses, tubes, etc.) and combinations of such components used to connect the remote steering control system components to the remainder of that system should be designed to meet the following requirements.

#### 4.6.1 Control Box Components

Components leaving the control box should be protected against damages in normal use such as door opening/closing, catching on wheelchair components, etc. (see Section A.3).

*Rationale:* Many remote steering control systems have components which could be easily snagged by wheelchair control boxes, armrests, leg rests, etc., which could disconnect them when the driver backs out to the driving station. Some control components have been caught in closed doors, pinching them closed. This requirement is designed to reduce that danger. Looms or bundling have not been specified because it was felt that, in some cases, it would reduce the effectiveness of redundancy to have redundant components bundled.

#### 4.6.2 Sufficient Slack

All such components should be removable, detachable, or have sufficient length to accommodate all normal motion of parts to which they are attached and not subject the components to stretching, chafing, or bending which could harm the components (see Section A.3).

*Rationale:* This requirement is needed when control boxes are mounted on doors or swing-away platforms, made movable for removal of engine covers (for right side installations in vans), etc.

#### 4.6.3 Positively Attached

All connections of the remote steering control system to the control box, to other such components in the remainder of the remote steering control system, and to the vehicle should be positively attached and retained. All electrical and electronic connectors should be designed to maintain surety of connection while subjected to vibration, shock, and the extreme temperatures that are normal environmental conditions for motor vehicles. Surety of connection should be accomplished through the use of integral-molded lock devices, terminal-to-terminal interference (detents), secondary locking clips, or attaching devices (see Section A.3).

*Rationale:* Most components are critical for the proper steering operation of a vehicle modified for a person with a disability. Even though friction seems secure for many applications (especially where vacuum is concerned), these components are subject to vibration, inertia, and occasional tugs by the operator. Many operators of remote steering control systems may not have sensation or proprioception in their hands and may inadvertently contact a wire or tube without knowing it.

#### 4.6.4 Chafe Protection

All holes in the vehicle, the control box, or other systems through which components (wires, hoses, etc.) pass should protect those components from abrasion (see Section A.3).

*Rationale:* These components often pass through holes in the vehicle firewall, portions of the instrument panel, or the control box itself. Due to the critical nature of most such components, they should be protected.

#### 4.7 Vehicle Interface

Components of the remote steering control system that are attached to, or installed onto the vehicle, in order to install the remote steering system should not interfere with the function of the OEM vehicle (see Section A.3).

*Rationale:* The remote steering control system design should not require the user to operate the vehicle in a manner not in keeping with common practice in the industry. In addition, the modifications involved in the installation of the remote steering control system should not interfere with OEM functions.

#### 4.8 Limitation on Maximum Torque Output

The maximum torque output of the remote steering control at the OEM steering end-stops should not exceed 3.35 N·m (300 in-lb) as measured at the steering column shaft (see A.4.1.5).

*Rationale:* Remote steering controls can have the potential of exerting tremendous output torque. This output torque should be limited to avoid damage to OEM components.