



# SURFACE VEHICLE INFORMATION REPORT

J2672™

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(R) Reduced Effort Power Steering Modifications and  
Backup Systems (Hydraulic and/or Electric)

## RATIONALE

Performance standards and testing procedures are needed to guide adaptations to the hydraulic and electric steering for drivers with physical disabilities. This document has been revised to include document lists and wording for the inclusion of the technology of electric steering.

### 1. SCOPE

#### 1.1 Scope

This SAE Information Report relates to a special class of automotive adaptive equipment which consists of modifications to the power steering system provided as original equipment on personally licensed vehicles. These modifications are generically called "modified effort steering" or "reduced effort power steering." The purpose of the modification is to alter the amount of driver effort required to steer the vehicle. Retention of reliability, ease of use for physically disabled drivers and maintainability are of primary concern. As an Information Report, the numerical values for performance measurements presented in this report and in the test procedure in the appendices, while based upon the best knowledge available at the time, have not been validated.

#### 1.2 Classification

Steering modifications are classified as modification in which the power steering assist effort is altered. The modifications considered in this Information Report may be accomplished by electrical, hydraulic, or other means.

#### 1.3 Limitations and Inclusions

These recommendations are limited to modifications which are designed to utilize an OEM, electrical, mechanical, and/or hydraulic steering system for steering control.

1.3.1 This Information Report does include additional auxiliary power systems (henceforth referred to as power steering backup systems) which are installed to provide needed redundancy for backup/emergency operation.

1.3.2 Although other types of auxiliary power systems are possible, this Information Report deals only with electrical, mechanical, and/or hydraulic systems.

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- 1.3.3 Although the recommendations are limited to changes to the electrical, mechanical, and/or hydraulic power steering system and the power steering backup system, the modifications would be tested with an OEM steering column and steering wheel or the aftermarket manufacturer's recommendations.
- 1.3.4 Although it is possible to combine other steering wheel and/or steering column modifications with Reduced Effort Power Steering and Power Steering Backup Systems, those modifications will not be considered as a part of 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: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

|           |                                                                                 |
|-----------|---------------------------------------------------------------------------------|
| SAE J188  | Power Steering Pressure Hose - High Volumetric Expansion Type                   |
| SAE J189  | Power Steering Return Hose - Low Pressure                                       |
| SAE J190  | Power Steering Pressure Hose - Wire Braid                                       |
| SAE J191  | Power Steering Pressure Hose - Low Volumetric Expansion Type                    |
| SAE J771  | Automotive Printed Circuits                                                     |
| SAE J1211 | Handbook for Robustness Validation of Automotive Electrical/Electronic Modules  |
| SAE J1292 | Automobile and Motor Coach Wiring                                               |
| SAE J1673 | High Voltage Automotive Wiring Assembly Design                                  |
| SAE J2223 | Connections for On-Board Road Vehicle Electrical Wiring Harnesses-Parts 1, 2, 3 |
| SAE J2561 | Bluetooth™ Wireless Protocol for Automotive Applications                        |

#### 2.1.2 NHTSA Publications

Available from National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590, Tel: 1-888-327-4236, <https://www.nhtsa.gov/>.

|               |                                                              |
|---------------|--------------------------------------------------------------|
| FMVSS No. 201 | Occupant Protection in Interior Impacts.                     |
| FMVSS No. 203 | Steering Wheel Impact Protection.                            |
| FMVSS No. 204 | Steering Wheel Rearward Displacement                         |
| Part 595      | Exemptions from the Make Inoperative Prohibition; Final Rule |

### 2.1.3 Military Publications

Available from Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

MIL-STD-1472 (Rev. F) Department of Defense Design Control Criteria Standard: Human Engineering.

## 3. DEFINITIONS

### 3.1 ABLE-BODIED

A person without disabilities who does not require adaptive aids to operate a personally licensed vehicle.

### 3.2 ACTUATOR

A transducer whose output is a force or torque and usually involves motion.

### 3.3 AFTERMARKET MANUFACTURER

3.4 The manufacturer of adaptive devices that is not Original Equipment (OE) in a vehicle.

### 3.5 AUTHORIZED DEALER, FACILITY OR REPRESENTATIVE

The manufacturer of the adaptive devices has the responsibility to designate the qualifications needed to work on the system for installation and/or service.

### 3.6 BACKUP

Any device which duplicates or otherwise fulfills the function of another if the latter fails or becomes inoperative.

### 3.7 BOOSTER

Any device for increasing power or output.

### 3.8 CRASHWORTHINESS

Degree to which the interior of a motor vehicle, devices installed in the passenger compartment, and the structure of the vehicle as a whole minimize injury to an occupant in the event of a crash.

### 3.9 dBA

Decibels, referenced to the A scale of attenuation by frequency, which approximates the human ear: a measure of sound intensity.

### 3.10 FEEDBACK

The recycling of a portion of the output to the input of a system. Systems employing feedback are called closed loop systems.

### 3.11 GEAR BOX

A transmission assembly comprising gear sets providing mechanical advantage or torque multiplier also includes rack and pinion systems. Within this document it includes both Steering Gear Box and Steering Rack and Pinion systems.

### 3.12 GEAR RATIO

The ratio of the angular velocity of meshed gears.

### 3.13 INPUT

The force exerted by the driver to the steering system to create mechanical movement to the vehicle steer wheels.

### 3.14 JOYSTICK

Any of a class of primary vehicle controls which substitutes a lever or tiller for the steering wheel. Some joysticks also incorporate control of throttle and brake functions as well.

### 3.15 LOCK-TO-LOCK

Excursion of the front wheels of a motor vehicle from full left extent of travel to full right extent of travel.

### 3.16 LOGIC

Components in a system which have a decision-making function, or which perform switching activities based on certain conditions or events.

### 3.17 LOGO

A manufacturer's name or trademark.

### 3.18 LOW EFFORT

An input that is less than the OE required steering force but higher than "Zero Effort."

### 3.19 MAJOR ASSEMBLY

Functional unit of a system, such as a pump, steering wheel, steering gearbox, or reservoir. Each major assembly is made up of several parts or components.

### 3.20 NOMINAL

Normal or acceptable, within acceptable limits.

### 3.21 ORIGINAL EQUIPMENT

See OEM.

### 3.22 OEM

Original Equipment Manufacturer refers to the vehicle and its systems as they are designed and produced by the automobile manufacturer.

### 3.23 POWER STEERING CONTROL VALVE

That part of the steering gearbox or connected to the steering gearbox which controls the admission of hydraulic fluid under pressure to the actuator which in turn moves the steering linkage of the motor vehicle. This valve is mechanically connected to the steering wheel through a feedback spring, and to the resultant output from the steering linkage.

### 3.24 PRIMARY

Pertaining to the system which is intended to be in operation normally or routinely.

### 3.25 POWER STEERING BACKUP SYSTEM

An electric, mechanical, and/or hydraulic backup system for the OEM or aftermarket provided power steering system and/or peripheral components.

### 3.26 PROTOCOL

A set of procedures to be followed.

### 3.27 REDUCED EFFORT POWER STEERING

A modified OEM power steering system with lower effort required to steer the vehicle. This term includes both “Low Effort Power Steering System” and a “Zero Effort Power Steering System.”

### 3.28 SHALL

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

### 3.29 SHOULD

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

### 3.30 SINGLE-POINT FAILURE

Any failure of a component which directly causes the system of which the failed component is a part to cease to function.

### 3.31 STEERING GEARBOX

A mechanism that translates the rotary input of the steering wheel into the resultant movement that controls the angle of the front wheels of a vehicle.

### 3.32 STEERING WHEEL

Any kind of device which controls vehicle direction by means of rotary motion.

### 3.33 ZERO EFFORT

Commonly reference to “NO” or “Minimum” effort input required to steer the vehicle.

## 4. DESIGN RECOMMENDATIONS

### 4.1 Conventional Use of Motor Vehicle

Reduced effort power steering and power steering backup system modifications should be designed to permit the conventional use of the steering wheel by drivers without disabilities. Driving after installation of equipment by a driver without disabilities may require training. (APPENDIX RTP 3.1)

### 4.2 Power Steering Back up

Altered power steering adaptation should incorporate a power steering backup system for altered power steering operation in case of primary power failure. If primary power steering failure occurs, the backup system should retain the altered steering effort.

#### 4.3 Reduced Effort Power Steering

##### 4.3.1 Maintenance of OEM Design Recommendations

- 4.3.1.1 Modifications should not introduce new single-point failures of the steering system that do not exist in the OEM system.
- 4.3.1.2 Whenever possible the modifications should not compromise or eliminate crashworthiness provisions provided by the vehicle manufacturer in compliance with Applicable FMVS/CMVS Standards.

##### 4.3.2 Torque Required for Steering

The torque required for steering control should be measured at the top of the steering shaft nut with vehicle powerplant engaged at the factory recommended curb idle “park” position (for IC engine with engine warm) and environmental conditions such as HVAC “off.”

This torque should be reduced from OE stock effort input to as low as 15.1 lb-in for steering designated as “low effort steering” and below 15.0 lb-in for steering designated as “zero” effort steering when tested with OEM wheels and tires on a dry smooth concrete surface. (APPENDIX RTP 5.1)

#### 4.4 Power Steering Backup Systems

##### 4.4.1 Automatic Activation

Automatic activation of the power steering backup system is recommended as a critical safety feature in the case of primary power steering system failure.

- 4.4.1.1 The power steering backup system should have automatic logic which can withstand a test of 2500 cycles of operation. (APPENDIX RTP 5.3.1)
- 4.4.1.2 When the power steering backup system is hydraulic it should also have automatic logic such that the system comes on within one second when an appropriate sensor detects a reduction or cessation of pressure or flow. Typical causes might be:
  - 4.4.1.2.1 Decay in flow and/or pressure (from, for instance, a fluid leak). (APPENDIX RTP 5.3.2.1)
  - 4.4.1.2.2 Sudden loss of flow and/or pressure (from, for instance, a broken belt or pump failure). (APPENDIX RTP 5.3.2.2)
  - 4.4.1.2.3 Cessation of flow and/or pressure (from, for instance a blockage in the line). (APPENDIX RTP 5.3.2.2.2)
- 4.4.1.3 The electric power steering backup system should also have automatic logic such that the system comes on within one second when an appropriate sensor detects a problem or failure due to any altered component or the altered system.
- 4.4.1.4 Safety features of the OEM electric power steering system shall not be altered.

##### 4.4.2 Acceptable Backup Power Sources

The power source for the primary steering system (usually the engine and related power transmission systems such as belts or batteries) should be functionally separate from the power source for the power steering backup system. The power steering backup system is powered by some source other than the primary power (e.g., an electric motor driven pump).

##### 4.4.3 Duty Time

The power steering backup system should provide power for steering with no support from the primary power source for a minimum of 5 minutes without serious overheating and damage. (APPENDIX RTP 6.1)

## 4.5 System Requirements Reduced Effort Power Steering and Power Steering Backup Systems

### 4.5.1 Leaks in Hydraulic Systems

Neither the reduced effort power steering nor the power steering backup system should display any significant leaks. (APPENDIX RTP 5.4)

### 4.5.2 Electrical Systems

Neither the reduced effort power steering nor the power steering backup system should have short circuits, abnormal current draws, or high resistance connections.

### 4.5.3 Operational Test

The combined reduced effort power steering system and power steering backup system should withstand a 2000 mile on-the-road test with no changes in the torque required for steering (IR 4.3.2). Hydraulic systems should not exhibit significant leakage (IR 4.5.1) or noticeable wear, fraying, or other anomalous conditions not present at the commencement of testing. Electrical systems should have equivalent or better current and voltage performance readings than at the commencement of testing.

### 4.5.4 Pressure Maintenance Capability on Hydraulic Systems

The pressure produced by the power steering backup system at the power steering gearbox inlet must not fall below the nominal pressure of the OEM power steering pump pressure delivery at the power steering gearbox inlet for the same steering input after 25 cycles of the steering wheel from lock-to-lock.

### 4.5.5 Maintenance Capability on Electric Systems

The electric power produced by the power steering backup system at the power steering motor must be equivalent or better than the nominal OEM power provided to the steering motor after 25 cycles of the steering wheel from lock-to-lock.

### 4.5.6 Hydraulic Fluid Cooling

#### 4.5.6.1 Allowed Temperature Rise

The combined reduced effort power steering and power steering backup systems should be able to withstand idling for at least 20 minutes without an increase in hydraulic fluid temperature to over 150 °C or a temperature specifically approved by the manufacturer of the fluid recommended. (APPENDIX RTP 5.6.1)

#### 4.5.6.2 Special Hydraulic Fluids

If a hydraulic fluid is used with an approved operating temperature over 150 °C, instructions to use that fluid should be permanently placed in a prominent position on the fluid reservoir, near the filler lid, as well as in the User's Manual. (APPENDIX RTP 2.2 and 3.13.5)

4.5.6.2.1 If special hydraulic fluid is required for extreme temperature operations, instructions to use that fluid should be permanently placed in a prominent position on the fluid reservoir, near the filler lid, as well as in the User's Manual.

## 5. MATERIALS AND COMPONENTS

### 5.1 Reduced Effort Power Steering

#### 5.1.1 Power Steering Power Source Quality

Primary power for the reduced effort power steering system should be an OEM power steering pump or electric motor for that vehicle or substitute with equal or better performance documented by an independent testing laboratory. (APPENDIX RTP 3.4 OEM Power Steering Power Source Quality)

#### 5.1.2 Power Steering Mechanism Quality

The power steering Mechanism which is modified for the reduced effort power steering system be an OEM power steering box for that vehicle or a substitute with equal or better performance documented by an independent testing laboratory. (APPENDIX RTP 3.5 OEM Power Steering Mechanism Quality)

*Rationale:* This recommendation is primarily to assure a minimal level of performance for the power steering box modified for the reduced effort power steering and for the power steering pump which will be used with the reduced effort power steering.

### 5.2 Power Steering Backup Systems

#### 5.2.1 Backup Power Steering Power Source Quality

Backup power source for the steering system for which the backup system is being installed should be an OEM power source or substitute with equal or better performance documented by an independent testing laboratory. (APPENDIX RTP 3.3 and 3.4)

*Rationale:* This recommendation is primarily to assure a minimum level of performance for the power steering power source which will be backed up by the power steering backup system. It is intended to avoid substitutions of inferior components due to space or other needs. This recommendation will usually be redundant with 5.1.1 but is needed when a backup system is fitted without a reduced effort steering system (for a driver who could operate OEM power steering, but not if the pump, belt, etc., failed).

#### 5.2.2 Electrical Components and Wiring

##### 5.2.2.1 Applicable Standards

Electrical components and wiring should conform to the SAE International Standards or Recommended Practices as applicable. Those listed below are applicable to the wiring of the electrical control system for the power steering backup system. (APPENDIX RTP 3.6.1)

SAE J258, SAE J553 - Circuit Breakers

SAE J1292 - Automobile Wiring

SAE J561, SAE J858a, SAE J928 - Electrical Terminals

Note to check current SAE standards

*Rationale:* It is expected that all equipment meets other applicable SAE Standards or Recommended Practices, even if this document is an Information Report.

##### 5.2.2.2 Packaging of Electrical Systems

All electrical systems should be designed and packaged to protect the driver or passengers against injury resulting from short circuits, electrical fires, and similar accidents. (APPENDIX RTP 3.9)

*Rationale:* The electrical systems have the potential to cause injury in a number of ways. Design consideration must be given to the prevention of such injuries.