SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Recommended Practice for Powered Gas Brake Control Systems

RATIONALE

As the National Highway Traffic Safety Administration (NHTSA) has become more involved with vehicle modifications, the need to assure registration of manufacturers of assistive devices, including powered gas/brake control systems, has become more essential.

1. SCOPE

This SAE Recommended Practice establishes a uniform procedure for assuring the manufactured quality, installed utility and performance of automotive powered gas/brake controls other than those provided by the vehicle manufacturer (OEM). These products are intended to provide driving capability to persons with physical disabilities. These products function as adaptive modifications to compensate for lost or reduced function in the extremities of the driver. Powered gas/brake control systems are not only designed to transfer foot functions to the hands or from one side of the body to the other, but to supplement by power, other than by the driver's own muscular efforts, the force output of the driver.

1.1 Inclusions

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

1.1.1 Operated by a vehicle driver with a physical disability.

1.1.2 Substitutes for the use of OEM vehicle accelerator and brake pedals, yet retains the OEM pedals for use by non-disabled drivers.

1.1.3 Output of the powered gas/brake device is applied to the OEM brake and gas assembly in order to change the force or range of motion required of the disabled driver.

1.1.4 All sections of this document are applicable to Group A primary controls.

1.2 Exclusions

This document is not applicable to any automotive adaptive product which:

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

1.2.2 Modifies the force and range of motion needed for operating a control by simple changes of leverage (such as manual driver controls).

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1.2.3 Is considered to be Group B primary controls or secondary controls.

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 powered gas/brake control system design, manufacture, installation, operation, maintenance and performance. Methods to measure those criteria are included in the accompanying Recommended Test Procedure (SAE J2604).

2. REFERENCES

2.1 Applicable Publications

Standards, specifications, and recommended practices (current revision) promulgated by the following agencies and cited herein are recommended in the design, manufacture, and use of automotive adaptive products. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org. All SAE standards referenced in this document can be found in the latest SAE Handbook or ordered as individual documents.

SAE J58 Flanged 12-Point Screws

SAE J78 Steel Self-Drilling Tapping Screws

SAE J81 Thread Rolling Screws

SAE J82 Mechanical and Quality Requirements for Machine Screws

SAE J122 Surface Discontinuities on Nuts

SAE J123 Surface Discontinuities on Bolts, Screws, and Studs in Fatigue Applications

SAE J174 Torque-Tension Test Procedure for Steel Threaded Fasteners—Inch Series

SAE J238 Nut and Conical Spring Washer Assemblies

SAE J429 Mechanical and Material Requirements for Externally Threaded Fasteners

SAE J474 Electroplating and Related Finishes

SAE J482 Hexagon High Nuts

SAE J483 High and Low Crown (Blind, Acorn) Hex Nuts

SAE J485 Holes in Bolt and Screw Shanks and Slots in Nuts for Cotter Pins

SAE J512 Automotive Tube Fittings

SAE J514 Hydraulic Tube Fittings

SAE J516 Hydraulic Hose Fittings

SAE J532 Automotive Straight Thread Filler and Drain Plugs

SAE J534 Lubrication Fittings

SAE J553 Circuit Breakers

SAE J561 Electrical Terminals—Eyelet and Space Type

SAE J773 Conical Spring Washers

SAE J858 Electrical Terminals Blade Type

SAE J891 Spring Nuts

SAE J892 Push-On Spring Nuts Inch Series—General Specifications

SAE J924 Thrust Washers—Design and Application

SAE J928 Electrical Terminals—Pin and Receptacle Type

SAE J933 Mechanical and Quality Requirements for Tapping Screws

SAE J995 Mechanical and Material Requirements for Steel Nuts

SAE J1053 Steel Stamped Nuts of One Pitch Thread Design—Inch Series

SAE J1153 Hydraulic Master Cylinders for Motor Vehicle Brakes—Test Procedures

SAE J1199 Mechanical and Material Requirements for Metric Externally Threaded Steel Fasteners

SAE J1231 Formed Tube Ends for Hose Connections and Hose Fittings

SAE J1237 Metric Thread Rolling Screws

SAE J1291 Automotive Hydraulic Brake System—Metric Banjo Bolt Connections

SAE J1292 Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring

SAE J1403 Vacuum Brake Hose

SAE J1508 Hose Clamp Specifications

SAE J1615 Thread Sealants

SAE J1638 Compression Set of Hoses or Solid Discs

SAE J1670 Type ‘F’ Clamps for Plumbing Applications

SAE J1808 Vacuum Power Assist Brake Booster Test Procedure

SAE J1926-1 Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 1: Threaded Port with O-Ring Seal in Truncated Housing

SAE J1926-2 Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 2: Heavy-Duty (S Series) Stud Ends

SAE J1926-3 Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 3: Light-Duty (L Series) Stud Ends

SAE J2241 Automotive Starter Drive Remanufacturing Procedures

SAE J2604 Recommended Test Procedure for Powered Gas Brake Control Systems

SAE HS 24 Motor Vehicle Braking Systems and Components

TSB002 Preparation of SAE Technical Reports

2.1.2 ANSI Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI/B 18.2.1 Hex Bolts

ANSI/ASME/B 18.2.2 Square and Hex Nuts (Supersedes SAE J104)

ANSI/B 18.6.1 Slotted and Recessed Head Screws (Supersedes SAE J478a)

ANSI/B 18.6.2 Slotted and Recessed Head Screws (Supersedes SAE J478a)

ANSI/B 18.6.3 Slotted and Recessed Head Screws (Supersedes SAE J478a)

ANSI/B 18.6.4 Slotted and Recessed Head Screws (Supersedes SAE J478a)

ANSI/B 18.22.1 Plain Washers (Supersedes SAEJ488)

2.1.3 ASME Publications

Available from ASME, 22 Law Drive, PO Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170, www.asme.org.

ASME B1.1 Threads and O-Ring Sealing—Part 1—Threaded Port with O-Ring Seal in Truncated Housing

ASME B1.1 Threads and O-Ring Sealing—Part 2—Heavy Duty (S Series) Stud Nuts

ASME B1.1 Threads and O-Ring Sealing—Part 3—Light Duty (L Series) Stud Nuts

2.2 Related Publications

The following publications are provided for information purposes and are not a required part of this document.

2.2.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org. All SAE standards referenced in this document can be found in the latest SAE Handbook or ordered as individual documents.

SAE J1113-1 Electromagnetic Compatibility Measurement Procedures and Limits for Components of Vehicles, Boats (up to 15 m), and Machines (Except Aircraft) (16.6 Hz to 18 GHz)

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 J1903 Automotive Adaptive Driver Controls, Manual

SAE J2094 Vehicle and Control Modifications for Drivers with Physical Disabilities Terminology

SAE 2388 Secondary Control Modifications

SAE J2588 Remote Steering Control Systems

SAE J2671 Reduced Effort Brakes and Reduced Effort Vacuum Powered Brake Backup Systems

SAE J2672 Reduced Effort Power Steering and Power Steering Backup Systems

2.2.2 American Society for Testing and Materials Publications

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B 117-1973 Method of Salt Spray (Fog) Testing

2.2.3 American Welding Society Publications

Available from AWS, 550 N.W. LeJeune Road, Miami, Florida 33126, Tel: 305-443-9353, www.aws.org.

AWS D1.1-72 Structural Welding Code

AWS D10.7-60 Recommended Practice for Gas-Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe

2.2.4 National Highway Traffic Safety Administration Publications

Available from NHTSA, U.S. Department of Transportation, 400 7th Street, S.W., Washington, DC 20590: Federal Motor Vehicle Safety Standards (FMVSS), Part 49, CFR 571.

FMVSS No. 101 Controls and Displays

FMVSS No. 105 Hydraulic Brake Systems

FMVSS No. 107 Reflecting Surfaces

FMVSS No. 124 Accelerator Control Systems

FMVSS No. 135 Service Brake System Performance

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

2.2.5 Military Standards

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-1472 Human Factors (Current Revision)

3. DEFINITIONS

For the purposes of this document, the following definitions apply.

3.1 Common Hand Tool

Hand-held 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 powered gas/brake control system which is mounted in the driver's space and on which the control handle is located. The function of the control box is to translate the motion of the control handle into some type of control information to be sent to the remainder of the system.

3.3 Control Handle

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

3.4 Driver's Space

The volume inside the vehicle occupied by the vehicle operator and containing all primary and secondary controls.

3.5 Electromagnetic Interference (EMI)

A condition in which sources of electromagnetic activity interfere with the function of equipment, subsystems, and systems. Also the condition in which such equipment, subsystems, and systems interfere with or produce unwanted electromagnetic activity, or in which different sources of electromagnetic activity interact with one another with consequent degradation of performance.

3.6 Emergency Backup

A device which can be used as a substitute for a primary system in the event of a failure of the primary system. While serving the same purpose, its design and performance may be different from that of the primary system.

3.7 Feedback

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

3.8 Primary or Secondary Controls

Controls are grouped based on the potential consequences of product failure. The groups are listed below in order of importance.

3.8.1 Primary Controls

3.8.1.1 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.

3.8.1.2 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.

3.8.2 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.

3.9 Manufacturer

The word manufacturer as used in this document, when not specifically being used otherwise, refers to the manufacturer of the Powered Gas Brake Control System.

3.10 Non-Disabled Driver

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

3.11 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.

3.12 Physical Disability

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

3.13 Powered

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

3.14 Powered Gas/Brake Control

A device which uses power from an energy source of the vehicle to supplement the force and motions made by the driver to control acceleration, velocity, and braking of a vehicle.

3.15 Product Literature

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

3.16 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.

3.17 Redundancy

The existence of more than one means of accomplishing a given function.

3.18 Primary Backup System

A device which can be used as a substitute for a primary system in the event of a failure of the primary system. It operates parallel (redundant) to the primary operating system and while its design could be significantly different, its performance is the same as the primary system

3.19 Response Time

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

3.20 Secondary Controls

(See 3.8.2 above)

3.21 Servo

A power device which amplifies control forces and automatically corrects the output in proportion to input.

3.22 Shall

Implies compliance is required; deviation is not permitted.

3.23 Should

Implies compliance is recommended; deviation is permitted.

3.24 Step Input

An input into a control system in which the entire input is made at one time, rather than as a gradual increase or an increase following a specific other wave form.

3.25 Unidirectional

Revolving, functioning, moving, or responsive in a single direction.

3.26 Visible Deformation

A change in alignment, position, or shape that is apparent to a careful observer.

4. PERFORMANCE REQUIREMENTS AND MANUFACTURING QUALITY

4.1 Powered Gas/Brake Control Brake Performance

The powered gas/brake control shall not degrade the performance attainable with the OEM unmodified brake system. Failure of the powered gas/brake control brake system to attain the deceleration or stopping distances attainable with the (OEM) power brake pedal using input forces on the control handle, specified by the control manufacturer, shall indicate non-compliance. (SAE J2604 Section 5.1.1.1g)

4.1.1 The control manufacturer shall specify the minimum input force required to operate the control handle, the location on the handle where the force is to be applied, and the corresponding travel of the control handle at that point, by incorporating them into their product literature. These force and travel specifications are to be the maximum needed for optimum braking and are intended to provide information to users about the system characteristics. SAE J2604 Sections 2.6 and 5.1.1.1.h)

4.1.2 The powered gas/brake control system shall be capable of exerting a minimum brake pedal force equivalent to 500 N (112.4 pounds) under the brake pedal pad at the end of pedal travel expected for the vehicle specified by the manufacturer as suitable for installation of the powered gas/brake control system. (SAE J2604 Section 5.1.1.2)

Rationale – These requirements are designed to ensure that whatever changes are made to the OEM vehicle to install the powered gas/brake control system and whatever changes this system may make in the ease of use of the gas and brakes for a person with a disability, the powered gas/brake control system does not degrade the braking performance of the OEM braking system available to the user compared to the use of the OEM braking system by able-bodied individuals.

4.2 Mandatory Primary Backup for Powered Gas/Brake Control

All powered brake control systems shall incorporate a redundant primary backup system.

4.2.1 A failure analysis shall be conducted to support the selection of the system components being backed up and what backup system will be provided. The manufacturer shall document the results of the failure analysis in a report which identifies the specific components (or subassemblies, etc.) selected for backup. (SAE J2604 Section 3.6)

4.2.2 The primary backup system for the control shall be isolated from the primary operating system to assure that failure of the primary system components will not cause a failure of the backup system. (SAE J2604 Section 5.1.3.1.1)

4.2.3 Redundant backup provisions should be made for gas, and shall be made for brake control. Such redundant backup provisions shall be sufficient for at least five minutes of operation under normal driving conditions. (SAE J2604 Sections 5.1.3.1.2, SAE J2604 Section 5.1.3.2.)

4.2.4 The manufacturer shall document, for use in the test procedure, the following information:

4.2.4.1 Identification of the components being backed up per the failure analysis submitted in SAE J2604 Section 2.6 for the powered gas/brake control. (SAE J2604 Section 3.6, SAE J2604 Section 5.1.3)

4.2.4.2 A means for disconnecting the control system components being backed up in such a way that it does not affect the performance of the OEM vehicle or harm the control system when the components are disconnected but allows the provided backup system to function. (SAE J2604 Section 3.6, SAE J2604 Section 5.1.3)

Rationale – The purpose of the backup requirement is to provide the disabled driver some of the same protection from failure available to a non-disabled driver with the original brake system. The able-bodied driver can retain a measure of braking capability in the event of loss of power boost. A disabled driver will not have this capability, since the modification covered herein is installed because of his/her inability to use the original equipment powered system.

4.3 Automatic Actuation of the Primary Backup Power

If the system components requiring backup, identified in the failure analysis for the powered gas/brake control system, become inadequate to meet the performance described in 4.1 above, due to the causes identified in the failure analysis (4.2.1 above), the means to stop the vehicle with the Primary backup power source shall be available without any additional control motions by the driver other than the use of the control lever. (SAE J2604 Section 5.1.3.1.3)

Rationale – If there is a problem with the control, the driver may be far too preoccupied to actuate a backup system manually. The automatic actuation will provide for continuing powered control service.

4.4 Automatic Actuation of an Emergency Backup Brake Actuator System

If the primary powered gas/brake control system fails, a means to stop the vehicle shall be available without any additional control motions by the driver other than the application of the brake. (SAE J2604 Sections 5.1.4.1, SAE J2604 Section 5.1.4.2)

Rationale – If the entire powered gas brake control system fails, the emergency backup brake system will provide a way to stop the vehicle without the driver taking their hand from the control.

4.5 Engine Shutoff Control

The driver shall have a means to shift to neutral and turn the engine/motor off independently at any time. (SAE J2604 Section 3)

4.5.1 The Backup System capabilities referenced in section 5.3 shall be maintained. (SAE J2604 Sections 5.1.3.1.4 and 5.1.3.2.c)

4.5.2 A means shall be provided to prevent inadvertent operation. (SAE J2604 Section 4)

4.6 Service Life

The powered gas/brake control system, when installed and maintained according to the manufacturer's instructions, is an integral part of the vehicle and shall perform for 70 000 cycles, which is as long and reliable as the OEM components of the vehicle to which it is originally attached. (SAE J2604 Section 5.2.4)

Rationale – SAE J1153 (for Hydraulic Master Cylinders) and J1808 for Vacuum Power Assist Brake Boosters) specify 70 000 cycle stroking tests.

4.7 Service Overload

The control handle shall not deform under loads which could be expected in anticipated driving conditions. (SAE J2604 Section 5.2.3)

Rationale – Occasionally, the powered gas/brake system control handle will be subjected to momentary overloads induced by the driver (panic stops, sudden hard acceleration, sudden changes of direction, loss of power assist), 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 powered gas/brake control system is expected to withstand such events with no resulting degradation of strength or performance.

4.8 Limitation on Maximum Output

The maximum force output of the powered gas/brake control on the OEM pedals shall not exceed 1330 N (300 pounds) to the brake pedal pad (or a proportionately higher force on other portions of the brake pedal arm) and 222 N (50 pounds) to the gas pedal pad (or a proportionately higher force on other portions of the gas pedal arm). (SAE J2604 Section 5.1.2.1, SAE Section 5.1.2.2)

Rationale – Powered controls have the potential of exerting tremendous output forces. These output forces shall be limited to avoid damage to OEM control linkages, master cylinders etc. The force was allowed to be as high as 300 pounds for manufacturers who wanted to have their powered control stop a vehicle when the OEM power brake booster has failed.

4.9 Electromagnetic Interference

The powered gas/brake control shall be designed to minimize the production of, or being affected by, EMI. The manufacturer shall have available documentation as to what provisions were made and how their effectiveness was measured. Installation procedures deemed by the manufacturer to be needed to assure the EMI protection obtained in the documentation shall be included in the installation manual. (SAE J2604 Sections 3.3, SAE J2604 Section 3.6)

Rationale – EMI can be emitted from some types of electronic devices, such as cellular telephones, which could interfere with control circuits. The widespread use of electronics in engine computers and antilock brake systems could also produce EMI. On the other hand, the powered control electronics could produce EMI with other adaptive devices or with the vehicle electronics.

4.10 Vibration Environment

The powered control, as installed according to the manufacturer’s instructions, shall continue to perform its intended function, without loosening of fasteners or adjustable components, and without loss of electrical function when subjected to a vibration test. (SAE J2604 Section 5.2.5)

Rationale – The components of a powered control system must survive an environment of shock and vibration in a moving vehicle. The system must be able to withstand these vibrational stresses in addition to the actual use cycles it will experience over time.

4.11 Effect on Performance

Based upon subjective observation, the location, weight, and positioning of the powered gas/brake control system shall not degrade the quality, handling characteristics, outward visibility, reliability, and efficiency of operation of the vehicle. (SAE J2604 Section 4, SAE J2604 Section 5.1.5)

4.12 Compatibility with Normal Vehicle Use

The design of the_powered gas/brake control system shall not impede or defeat the control of the vehicle by a driver without a disability using the OEM controls. (SAE J2604 Section 4)

4.13 Injurious Exposures

The user of the powered gas/brake control system and other occupants of the vehicle should not be subject to injury during normal product or vehicle movement due to contact with rough edges or burrs, projections or moving parts on the powered gas/brake control system or any pinching or crushing between components of the OEM vehicle and/or the control system. Particular attention shall be given to the proximity between moving components and the hands, feet and head of the vehicle occupants. (SAE J2604 Section 4)

Rationale – The design of the powered control system must not allow projections or movements of parts of the system to injure the user or occupants. For example, a brake actuator can not be mounted such that it could catch the user's foot between the actuator and the brake pedal.

4.14 Operator Safety

The installed powered gas/brake control system shall not offer unreasonable risk to the user, or to any other vehicle occupant, at any time during its operating cycle from electrical shock, burns, abrasive surfaces and parts that may exhibit extremes to temperature. (SAE J2604 Section 4)

Rationale – The design of the powered control system can not allow the intended user to be subjected to harm. For example, powered controls are often used by quadriplegics who usually have no sensation in their hands. Therefore, an unprotected metal input device located near the driver's side door window could get hot and burn the user when the user put his/her hand into or onto the device.

4.15 Maintenance

4.15.1 The manufacturer of the powered gas/brake control shall design and fabricate his system such that parts requiring user maintenance are readily accessible without major disassembly and using only common hand tools. Accessibility to OEM components of the vehicle requiring maintenance shall not be significantly degraded. (SAE J2604 Section 4)

4.15.2 If special purpose maintenance tools are needed for user maintenance of the powered control system, they shall be supplied as part of the powered control system. (SAE J2604 Section 3.4)

4.15.3 The design of the powered gas/brake control system shall consider possible wear and adjustment needs of the product and make appropriate accommodations for parts changing, adjustments, and lubrication. (SAE J2604 Section 4)

4.16 Accommodation for Wear

The design of the installed powered gas/brake control system shall incorporate a means of making adjustments, cleaning and lubrication that will prolong the useful life of the those components whose wear, abrasion, or corrosion may be expected to degrade the performance of the powered gas/brake control system. (SAE J2604 Section 4)

4.17 Environmental Resistance

Protective enclosures and coatings shall be utilized to protect against the effects of moisture, chemicals, dust and temperature extremes that may be expected to occur during the normal use of the powered gas/brake control system, both inside and outside the passenger compartment of the vehicle. (SAE J2604 Section 4)

4.18 Mechanical Finish

The installed powered gas/brake control system shall have no burrs, sharp edges, and rough surfaces resulting from forming, machining, or welding which might create stress concentrations on the surface of the control system. (SAE J2604 Section 4)

4.19 Packaging

The manufacturer shall provide packaging for shipping to the installer that will insure the protection of the powered gas/brake control system and its associated documentation against shipping hazards, including vibration, impact and moisture. (SAE J2604 Section 3.1)

4.20 Cleanliness

The powered gas/brake control system shall not present dirty, wet, or greasy surfaces inside the vehicle that can be contacted by the user or other vehicle occupants. (SAE J2604 Section 4)

Rationale – The design of the powered control system must not allow moving parts requiring lubrication etc., to be in close proximity to the user. For example, a brake actuator requiring lubrication on the outside of part of the actuator could easily rub off onto the user's leg or clothing.

4.21 Driver's Vision

The location and surface finish of the powered gas/brake control system shall avoid presenting any direct obstruction to, or reflection of bright light into, the field of view of the driver. (SAE J2604 Section 4)

4.22 Attachment

Installation of the powered gas/brake control system shall not require alterations to the vehicle which diminish the structural integrity of the vehicle components. (SAE J2604 Section 4)

4.23 Clearance

The space between parts of the installed powered gas/brake control system and the vehicle shall be adequate to allow access to vehicle components for normal use and service. (SAE J2604 Section 4)

4.24 Vehicle Interface

Components of the powered gas/brake control system that are attached to, or installed onto the vehicle, in order to install the powered gas/brake system shall not interfere with the function of the OEM vehicle. (SAE J2604 Section 4)

Rationale – The user needs to be able to operate the powered control system design in a manner keeping with common practice in the industry. In addition, the modifications should not interfere with OEM functions.

4.25 Control Box Connections

All components (wires, hoses, tubes etc.) and combinations of such components used to connect the powered gas/brake control system control box to the remainder of that system shall be designed to meet the following requirements.

4.25.1 Control Box Components

Components leaving the control box shall be protected against damages in normal use such as door opening/closing, catching on wheelchair components, etc. (SAE J2604 Section 4)

Rationale – Many powered gas/brake control systems have components which could be easily snagged by wheelchair control boxes, armrests, legrests, etc. which could disconnect them when the driver backed 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.

4.25.2 Sufficient Slack

All such components shall 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. (SAE J2604 Section 4)

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

4.25.3 Positively Attached

All connections of such components between the control box and other subassemblies of the powered gas/brake control system and to the vehicle shall be positively attached and retained. Where threaded, bonded, or press fit connections are not used, clamps or other suitable methods of maintaining connection integrity shall be employed. All electrical and electronic connectors shall 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 should be accomplished by employing the use of integral-molded lock devices, terminal-to-terminal interference (detents), secondary locking clips, or attaching devices. (SAE J2604 Section 4)

Rationale – This is necessary due to the criticality of most such components to the proper operation of the brakes and accelerator of the vehicle for the disabled operator. 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 such powered gas/brake control systems may not have sensation or proprioception in their hands and may hit a wire or tube without knowing it.

4.25.4 Chafe Protection

All holes in the vehicle, the control box or other systems through which such components pass shall protect those components from abrasion. (SAE J2604 Section 4)

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 need to be protected.

5. MATERIALS AND COMPONENTS

5.1 Electrical Components and Wiring

5.1.1 Applicable Standards

Electrical components and wiring shall conform to the Society of Automotive Engineers Standards or Recommended Practices as applicable. Those listed below are applicable to the wiring of the electrical control system for the powered gas/brake control system.

SAE J553 Circuit Breakers
SAE J561 Electrical Terminals—Eyelet and Space Type
SAE J858 Electrical Terminals Blade Type
SAE J928 Electrical Terminals—Pin and Receptacle Type
SAE J1292 Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring

Rationale – It is expected that all equipment designed to an SAE Standard or Recommended Practice meet other applicable SAE Standards or Recommended Practices.

5.2 Protection of Hoses

Hoses or tubing shall be protected from rubbing on any components or bearing on exhaust system components. (SAE J2604 Section 3)

Rationale – One frequent cause of hose or tubing failure is improper contact with other vehicle components.

5.3 Fittings and Hoses

All vacuum fittings, hoses and tubing shall conform to the Society of Automotive Engineers Standards or Recommended Practices or other noted standards, as applicable.

SAE J512 Automotive Tube Fittings
SAE J514 Hydraulic Tube Fittings
SAE J516 Hydraulic Hose Fittings
SAE J532 Automotive Straight Thread Filler and Drain Plugs
SAE J534 Lubrication Fittings
SAE J1231 Formed Tube Ends for Hose Connections and Hose Fittings
SAE J1403 Vacuum Brake Hose
SAE J1508 Hose Clamp Specifications
SAE J1615 Thread Sealants
SAE J1638 Compression Set of Hoses or Solid Discs
SAE J1670 Type 'F' Clamps for Plumbing Applications
SAE J1926-1 Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 1: Threaded Port with O-Ring Seal in Truncated Housing
SAE J1926-2 Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 2: Heavy-Duty (S Series) Stud Ends
SAE J1926-3 Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 3: Light-Duty (L Series) Stud Ends
SAE J2241 Automotive Starter Drive Remanufacturing Procedures
SAE HS 24 Motor Vehicle Braking Systems and Components
ASME B1.1 Threads and O-Ring Sealing—Part 1—Threaded Port with O-Ring Seal in Truncated Housing
ASME B1.1 Threads and O-Ring Sealing—Part 2—Heavy Duty (S Series) Stud Nuts
ASME B1.1 Threads and O-Ring Sealing—Part 3—Light Duty (L Series) Stud Nuts

5.4 Fasteners

All mechanical fasteners used for the manufacture and installation shall conform in type, strength, vibration, and corrosion resistance to the following SAE fastener standards.

ANSI/ASME/B 18.21	Lock Washers (Supersedes SAE J489)
ANSI/ASME/B 18.2.2	Square and Hex Nuts (Supersedes SAE J104)
ANSI/B 18.2.1	Hex Bolts
ANSI/B 18.6.1	Slotted and Recessed Head Screws (Supersedes SAE J478a)
ANSI/B 18.6.2	Slotted and Recessed Head Screws (Supersedes SAE J478a)
ANSI/B 18.6.3	Slotted and Recessed Head Screws (Supersedes SAE J478a)
ANSI/B 18.6.4	Slotted and Recessed Head Screws (Supersedes SAE J478a)
ANSI/B 18.22.1	Plain Washers (Supersedes SAEJ488)
SAE J58	Flanged 12-Point Screws
SAE J78	Steel Self-Drilling Tapping Screws
SAE J81	Thread Rolling Screws
SAE J82	Mechanical and Quality Requirements for Machine Screws
SAE J122	Surface Discontinuities on Nuts
SAE J123	Surface Discontinuities on Bolts, Screws, and Studs in Fatigue Applications
SAE J174	Torque-Tension Test Procedure for Steel Threaded Fasteners—Inch Series
SAE J238	Nut and Conical Spring Washer Assemblies
SAE J474	Electroplating and Related Finishes
SAE J482	Hexagon High Nuts
SAE J483	High and Low Crown (Blind, Acorn) Hex Nuts
SAE J485	Holes in Bolt and Screw Shanks and Slots in Nuts for Cotter Pins
SAE J773	Conical Spring Washers
SAE J891	Spring Nuts
SAE J892	Push-On Spring Nuts Inch Series—General Specifications
SAE J924	Thrust Washers—Design and Application
SAE J933	Mechanical and Quality Requirements for Tapping Screws
SAE J995	Mechanical and Material Requirements for Steel Nuts
SAE J1053	Steel Stamped Nuts of One Pitch Thread Design—Inch Series
SAE J1199	Mechanical and Material Requirements for Metric Externally Threaded Steel Fasteners
SAE J1237	Metric Thread Rolling Screws
SAE J1291	Automotive Hydraulic Brake System—Metric Banjo Bolt Connections

5.4.1 Fastener Grade

All nuts and bolts used during manufacture or installation for structural purposes shall have a locking system used where indicated and shall be grade 5 or better. (SAE J2604 Section 4)

5.4.2 Operational Testing of Fasteners

Fasteners shall be considered an integral part of a powered gas/brake control System and shall have been tested for wear, integrity, loosening or loss through vibration, use conditions, or corrosion. Torque specifications for all mounting fasteners shall be furnished by the manufacturer. (SAE J2604 Sections 3.6 and 5.2.6)

Rationale – It is expected that all equipment designed to an SAE Standard or Recommended Practice meet other applicable SAE Standards or Recommended Practices. Many of the components of the powered gas/brake control are subject to stress, vibration and other conditions which can lead to various forms of fastener failure. The potential for system failure subsequent to fastener failure is quite high.

5.5 Furnished Peripheral Components

All labels, switches, lights, fasteners, specialized tools for user maintenance, mounting hardware, wires, vacuum hoses etc. (except fluids and batteries with associated battery control devices) needed for the powered gas/brake control system shall be furnished with the system shipped by the adaptive equipment manufacturer. (SAE J2604 Section 3.4)

Rationale – The standard hoses, switches etc. which are available locally to installers, may not be adequate to the pressures and temperatures possible within a powered gas/brake control system. Installers may not have the equipment to make proper labels and may not be aware of the requirements for many of the labels.

5.6 Modified OEM Parts

Any components manufactured by an OEM, or other purchased components, which have been internally modified and included in the powered gas/brake control installation parts kit shall have warnings on the component (or assembly of parts) indicating that they have been modified and shall not be replaced with OEM components or other unmodified components. (SAE J2604 Section 3.5)

6. OPERATION

6.1 Control Predictability

The output of the powered gas/brake control system as applied to the OEM components shall bear a repeatable relationship to the inputs.

6.1.1 Repeatability

A given input to the powered gas/brake control shall cause a repeatable corresponding output to the OEM system. (SAE J2604 Section 5.2.1.1)

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

6.1.2 Constant Input Response

If the input to the control handle (be it force or motion) does not change, there shall not be any changes in output to the OEM system. (SAE J2604 Section 5.2.1.2)

6.1.3 Response Time to Input

The powered gas/brake initial response time for the gas or brake shall not exceed 0.1 second. (SAE J2604 Section 5.2.1.3)

6.1.4 Gas-to-Brake Response Time

6.1.4.1 For single-lever control systems, the powered gas/brake response time to a change in control input from full gas to full brake shall not exceed 0.4 second. (SAE J2604 Section 5.2.1.4g)

6.1.4.2 The manufacturer shall document, for use in the test procedure, the following information:

6.1.4.2.1 A static unidirectional load representing the full application of brakes. (SAE J2604 Section 3.6)

6.1.4.2.2 A static unidirectional load representing the full application of accelerator. (SAE J2604 Section 3.6)

Rationale – This is to insure that the control system does not introduce undesirable changes in the output causing the operator to have to search for the correct position of the control mechanism to maintain a steady state vehicle control. This does not require the system to act as a "cruise control", maintaining the same speed, acceleration or deceleration, regardless of conditions. It does mean however that if the control handle is maintained in the same position, the position of the OEM portion of the accelerator and brake systems does not change.

6.2 No Operator Adjustments

The powered gas/brake control system shall not have any adjustments (other than control inputs) which can be accomplished by the operator while the vehicle is in motion. (SAE J2604 Section 5.1.6)

Rationale – The potential for creating a dangerous control situation while on the road overrides the potential advantage of providing the operator with the option of fine tuning a system while driving.

6.3 Control Output Return to Null

6.3.1 If the operator releases the control handle, the control handle shall return to the null (normally center) position. (SAE J2604 Section 5.2.2.1)

6.3.2 The powered gas/brake control system shall not compromise OEM compliance with Federal Motor Vehicle Safety Standards 124. (SAE J2604 Section 5.2.2.2)

Rationale – Federal Motor Vehicle Safety Standard 124 is being interpreted by the National Highway Traffic Safety Administration (NHTSA) as applying to all devices that affect accelerator control systems.

6.4 Warning Label

The manufacturer shall supply a label with the powered gas brake control which states "WARNING - THIS VEHICLE IS EQUIPPED FOR A DRIVER WITH A DISABILITY. DO NOT OPERATE WITHOUT PROPER INSTRUCTIONS". The label shall comply with RP 6.8. If the label is not on the control, the installation manual shall state where it is to be placed. (SAE J2604 Sections 3.3 and 4)

Rationale – Powered gas/brake controls offer a method of control within the driver's space, which vastly change the way the braking, and acceleration of the vehicle feels. Individuals who are not familiar with the vehicle, (non disabled drivers, family, mechanics) need to be warned to expect something different.

6.5 User Manual

With every powered gas/brake control system the manufacturer or modifier shall provide a detailed user manual. The manual shall include the following items.

6.5.1 Description of the Control

What the control was designed to do and a simple explanation of how it works. (SAE J2604 Section 3.2)

6.5.2 User Operation

Cautions concerning use by drivers other than the intended driver, interpretation of warning lights, gauges or other warning indicators, a description of all manual and automatic modes and proper operating procedures for manual modes (including indications for manual operation of the system when manual operation is offered). Guidance for trouble-shooting that the user could be expected to do is also included under user operation. (SAE J2604 Section 3.2)