TWC Standards for Vehicle Modifications

4.1 Scope, Classifications, Limitations, and Definitions

4.1.1 Scope

This standard is applicable to automotive adaptive equipment and vehicle modifications subject to purchase in whole or in part by the Texas Work Force Commission (TWC) Vocational Rehabilitation Division (VRD) on behalf of eligible customers who require such adaptive equipment and modifications in order to drive or ride as a passenger in a personal licensed vehicle.

This standard covers all devices, mechanisms, and additions to a motor vehicle which can be installed in and/or on a motor vehicle as an after-manufacturer purchased item. The purpose of the adaptive equipment is to permit a person with a disability to safely operate or ride as a passenger in a private motor vehicle on public highways. Such adaptation includes devices and provisions for entering and exiting a motor vehicle, operating the vehicle or components of the vehicle, and restraint of drivers and passengers with disabilities and associated equipment such as wheelchairs, canes, walkers, etc.

This standard also covers modifications to existing subsystems of a motor vehicle in order to affect adaptation for the driver or passenger with a disability. These subsystems include but are not limited to electrical, mechanical, control, display, and structural components.

Adaptive equipment which does not conform to these standards or is not addressed by these standards may be accepted by the TWC VRD Program Specialist for Rehabilitation Technology (PSART) on an individual basis with prior documentation and demonstration of the equipment's suitability for the particular customer. The TWC VRD PSART has final approval of acceptability of adaptive equipment and vehicle modifications. At the TWC VRD PSART’s option, any adaptive device or modification may be required to be submitted to an independent test and evaluation agency for evaluation before the adaptive device or modification is accepted for purchase for eligible TWC VRD customers. In adoption of these Standards the TWC VRD's primary goal is maximum safety to drivers, passengers, and the motoring public.

4.1.2 Classifications

Automotive adaptive equipment is classified as follows:

Primary Controls

- Hand Controls
- Steering Assist Devices
- Steering Column and Shaft Extensions
- Steering Modifications
- Foot Steering
- Braking Modifications
- Left Foot Accelerator
- Pedal Extensions
- Powered Primary Controls

Secondary Controls

- Secondary Control Panels and Systems
- Transmission
- Turn Signals
- Hazard Warning Signals
- Windshield Wiper/washer
- Ignition and Engine Start
- Lights
- Seat Adjustment
- Power Windows
- Heating, Ventilation and Air
- Conditioning (HVAC) Controls
- Door Locks
- Parking Brake
- Horn
- Cruise Control
- Mirrors
- Rear Accessories

Access Devices

- Automatic Wheelchair Lifts
- Semi-Automatic Wheelchair Lifts
- Exterior Access Device Controls
- Automatic Door Openers
- Ramps
- Personal Lifting Devices
- Steps
- Assist Handles

Mobility Aid Handling Devices

- Racks
- Hoists

Occupant Protection

- Seats
- Passenger Restraints
- Mobility Aid Tiedowns (Occupied)
- Mobility Aid Tiedowns (Unoccupied)

Vehicle Structural Modification

- Flooring

- Lowered Floor Vehicle (Separate Body and Frame)
- Lowered Floor Vehicle (Uni-body)
- Fuel Tanks
- Lowering Pan
- Raised Roofs
- Modified Doors

Vehicle Electrical Modification

- Battery and Charging Systems
- Other Electrical Modifications

4.1.3 Limitations

These standards are limited to automotive adaptive equipment and vehicle modifications that are made after original equipment manufacture (OEM), non-OEM additions, or modifications to a motor vehicle for the purpose of private transportation. Also excluded from coverage under this standard is adaptive equipment or modifications to any vehicle not defined as a passenger automobile, passenger van, or truck under Texas Motor Vehicle Laws.

TWC VRD does not take any responsibility nor will the TWC VRD act as a review agency for any other entity which accepts or adopts any part or all of these Standards.

4.1.4 Definitions

For other definitions, please consult SAE J2094; however where definitions may conflict between J2094 and these Standards, the definitions herein shall govern.

Accessible
: The property of being able to be reached, operated and maintained by the user of the equipment.

Accommodation
: The space that is provided for the user.

ADA
: Americans With Disabilities Act.

Anchorage
: The final point of attachment for transferring seat belt assembly or wheelchair tiedown loads.

Actuator
: Any mechanism for controlling or moving a component indirectly or at a distance from the input.

Ambient
: That which is all around an object, such as air, and the condition of that surrounding at a given time.

Anthropometry

The dimensions, angles, area, volume, strength, and other physical characteristics of the human body.

Automatic Door Opener

Automatic door openers are any powered device which opens and closes vehicle doors to enable access to the vehicle.

Automotive Adaptive Equipment

Any device or mechanism which permits a person with a disability to gain or regain driving capability and /or use a motor vehicle independently or with assistance.

AWS

American Welding Society

Back-up

Any device which duplicates or otherwise fulfills the function of another device, at least temporarily, if the primary device fails or becomes inoperative.

Back-up Camera

Any video device which duplicates or otherwise fulfills the function of the rear view mirror.

Battery, primary

A non-rechargeable chemical device for providing electrical power which must be replaced when depleted.

Battery, storage

A chemical device for storing and delivering electrical power that can be recharged repeatedly.

Bezel

The trim ring around a gauge or control by which it is mounted in a panel.

Closed-Loop

See feedback loop.

Controls

Any device that accepts an input from a human being for the purpose of changing the state of the equipment to which the control is connected.

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 are designed to minimize injury to a passenger in the event of a crash.

Criterion

A rule or a test by which anything is tried in forming a correct judgment respecting it.

TWC VRD

TWC Vocational Rehabilitation Division, an agency of the State of Texas.

Deploy

To extend or put something out.

Display

A device that imparts information to a human being for the purpose of operating a piece of equipment.

Durability

The quality of being able to last or withstand the wear and tear of being operated or used.

Dynamic
: Active, moving, changing, as opposed to static.

Egress
: Exit from a vehicle or enclosure by a human being.

Electromagnetic Interference
: (EMI) Any electrical or electronic signal that can cause disruption or damage to an electronic device.

Electromechanical
: Equipped with both mechanical and electrical components to accomplish the function.

Electronic
: Operated by electron flow and/or logic.

Eligible customer
: A person with a disability who has met eligibility criteria and for whom a Plan has been formalized to receive vehicle modification services from TWC DRS.

Ergonomics
: The technology of designing equipment so it can be operated in the most effective and error free manner by the intended user.

Failure mode
: A way in which an item of equipment or device can fail, break or otherwise cease to function.

Feedback loop
: The return to the input of a particular system of part of the output for the purpose of correcting the output to match the input

FMVSS
: Federal Motor Vehicle Safety Standards

G force
: The force acting on an object or body due to acceleration or deceleration of that body measured in multiples of that body's weight.

Gain
: The ratio of the output of a system to the input to that system, when both are expressed in the same units of measurement.

Gauge
: The thickness of a sheet of metal, specifically the U. S. Standard Sheet Metal Gauge (or gage) system. The thicknesses in this system varies from 0.0062 inch (38 gauge) to 0.5 inch (0 000 000 gauge).

Hatch
: A small door or opening to gain access.

Human Factors
: See ergonomics.

Hydraulic
: Operated, moved or effected by means of a fluid under pressure or in motion.

Ingress
: To enter or get into a vehicle or other compartment.

Instrumentation
: Devices for detecting and/or measuring some quality or state under observation.

Integrated Circuit
: A tiny complex of electronic components and their connections that is produced in or on a single slice of material such as silicon.

Interface
: The place at which independent systems meet, act on, or communicate with one another. One of the driver/vehicle interfaces is the primary control group: throttle, brake, and steering.

Lag
: The delay between input and output inherent in any system, which usually becomes larger as input changes becomes more frequent; to fall behind.

Liability
: Obligation or responsibility according to law or equity.

Light Emitting Diode (LED)
: A solid state electronic device which glows when a current passes through it.

Light Crystal Display (LCD)
: A solid state electronic device which changes reflectance when a current passes through it.

Maintainability
: Design considerations directed toward accomplishing necessary maintenance quickly, safely, accurately, and effectively with minimum requirements for personnel, skills, special tools, and cost.

Nonskid
: Surface treatment to render friction between a surface and an object moving across the surface as high as possible.

OEM
: Original Equipment Manufacturer

Operability
: Design or installation considerations directed toward making a device capable of being controlled or made to work by the person for whom the device is designed.

Position control (zero order)
: Any system which responds to a change in the position of the control by a corresponding change in the position of the component being controlled, such that the ratio of output displacement and input displacement is a constant.

Pneumatic
: Using the power of compressed air or other gas to actuate or accomplish some function.

Processor
: Any device which performs logical operations on input information or otherwise operates on data. Essentially a dedicated purpose computer.

Program Specialist
: An employee of TWC VRDwho plans, develops, and coordinates policies and procedures for vehicle modification services.

Quality control

Activities designed to ensure adequate performance, durability, and finish in a manufactured product.

Reliability
: The quality of being dependable in operation within the stated operational limits probability that a system will perform a required function under specified conditions for a specified period or at a given time.

Safety
: Freedom from conditions which can cause injury or death to humans and damage to property. The conservation of human life and its effectiveness, and the prevention of damage to property consistent with product or system requirements.

Schematics
: Drawings or other diagrammatic representations of equipment.

Semi-Automatic Wheelchair Lift
: Designed to be operated by a person who is not being raised or lowered by the lift, e.g., an attendant, and is not suitable for independent drivers who have a disability.

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

Single Point Failure
: Any failure mode that in happening results in hazard or otherwise adversely affects the safe operation of the system.

Subsystem
: A combination of parts which performs an operational function within a system and is usually a major subdivision of that system.

System
: A composite of equipment capable of performing or supporting an operational role. A complete system includes all equipment, services, and personnel (e.g., the driver) required for its operation and support to the degree that it can be considered to be a self-sufficient unit in its intended operational environment. An automobile with a driver behind the wheel comprises a system.

TTI
: Texas A&M Transportation Institute, an agency of the Texas A&M University System

Toggle Switch
: An electrical device which a person uses as a control for an electrical or electronic circuit. The device has a short handle to permit the operator to select one of several states for the controlled circuit.

Torque
: A force which produces or tends to produce rotation or torsion; a turning or twisting force.

Uni-body
: Designating or of a type of construction used in motor vehicles, in which the floor, roof, panels, etc. are welded together into one unit, thereby eliminating the need for a separate frame.

Vacuum

A space partially empty of air such that the pressure in the space is below that of the surrounding air; this pressure difference is used as a source of power.

Vehicle Dynamics

The way in which a vehicle moves or responds to control inputs.

Warranty

A written guarantee of the integrity of a product and of the makers responsibility for the repair or replacement of defective parts

Weldment

Any joint or seam between two pieces of metal which are joined through heating the two metals and forcing them to flow together.

Zero order

See position control

4.2 Applicable Documents

Specifications or recommended practices (latest update) published by the following agencies and organizations and specified herein are applicable to the design, manufacture, supply, installation, and use of automotive adaptive equipment and vehicle modifications.

4.2.1 Department of Veterans Affairs, Washington DC

These can be provided by the TWC VRD PSART upon request.

- **VAPC-A-7505-8**—VA Standard Design and Test Criteria for Safety and Quality of Special Automotive Driving Aids (Adaptive Equipment) for Standard Passenger Automobiles
- **VAREC-A-8909-1**—(Draft) VA Standard Design and Test Criteria for Safety and Quality of Power Assisted Brake Modifications for Passenger Motor Vehicles
- **VAREC-A-8210-1**—(Draft) VA Standard Design and Test Criteria for Safety and Quality of Power Assisted Steering Modification for Passenger Motor Vehicles

4.2.2 Society of Automotive Engineers, 400 Commonwealth Drive Warrendale, PA 15096

- **SAE J190**—Power Steering Pressure Hose - Wire Braid
- **SAE J383**—Motor Vehicle Seat Belt Anchorages - Design Recommendations
- **SAE J514**—Hydraulic Tube Fittings
- **SAE J516**—Hydraulic Hose Fittings
- **SAE J517**—Hydraulic Hose
- **SAE J518**—Hydraulic Flanged Tube, Pipe, and Hose Connections, 4-Bolt Split Flange Type
- **SAE J1138**—Design Criteria - Driver Hand Controls Locations
- **SAE J1139**—Direction of Motion Stereotypes for Automotive Hand Controls

- **SAE J1176**—External Leakage Classifications for Hydraulic Systems
- **SAE J1211**—Recommended Environmental Practices for Electronic Equipment Design
- **SAE J1273**—Recommended Practices for Hydraulic Hose Assemblies
- **SAE J1292**—Automobile, Truck, Truck-tractor, Trailer, and Motor Coach Wiring (superseded by J2174 and J2202
- **SAE J1402**—Automotive Air Brake Hose and Hose Assemblies
- **SAE J1403**—Vacuum Brake Hose
- **SAE J1725**—Structural Modifications for Personally Licensed Vehicles to Meet Transportation Needs of Persons with Disabilities
- **SAE J1903**—Automotive Adaptive Driver Controls, Manual
- **SAE J2093**—Design Considerations for Wheelchair Lifts for Entry to or Exit from a Personally Licensed Vehicle
- **SAE J2094**—Vehicle and Control Modifications for Drivers with Physical Disabilities Terminology
- **SAE J2174-**Heavy Duty Wiring Systems for Trailers more than 2032 MM or More in Width
- **SAE J2202-** Heavy Duty Wiring Systems For On Highway Trucks.
- **SAE J2249**—Wheelchair Tiedown and Occupant Restraint Systems for Use in Motor Vehicles

4.2.3 American Welding Society, 2501 N.W. 7th St., Miami, FL 33125

- **AWS D1.1**—Structural Welding Code
- **AWS D10.7**—Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe

4.2.4 National Highway Traffic Safety Administration

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

- **FMVSS 101**—Controls and Displays
- **FMVSS 102**—Transmission Shift Lever Sequence, Starter Interlock, and Transmission Braking Effect
- **FMVSS 104**—Windshield Wiping and Washing Systems
- **FMVSS 105**—Hydraulic and Electric Brake Systems
- **FMVSS 106**—Brake Hoses
- **FMVSS 107**—Reflecting Surfaces
- **FMVSS 108**—Lamps, Reflective Devices, and Associated Equipment
- **FMVSS 114**—Theft Protection
- **FMVSS 124**—Accelerator Control Systems
- **FMVSS 126**—Electronic Stability Control
- **FMVSS 201**—Occupant Protection in Interior Impact

- **FMVSS 203**—Impact Protection for the Driver from the Steering System Control
- **FMVSS 204**—Steering Control Rearward Displacement
- **FMVSS 206**—Door Locks and Door Retention Components
- **FMVSS 207**—Seating Systems
- **FMVSS 209**—Seat Belt Assemblies
- **FMVSS 210**—Seat Belt Assembly Anchorages
- **FMVSS 214—**Side Impact Protection
- **FMVSS 301**—Fuel System Integrity
- **FMVSS 302**—Flammability of Interior Materials

4.2.5 U. S. Department of Defense, Washington, DC 20301

MIL-STD-1472—Military Standard--Human Engineering Design Criteria for Military Systems, Equipment and Facilities

4.2.6 Americans with Disabilities Act (ADA) of 1990

U. S. Dept of Transportation, Office of the Secretary of Transportation, Washington, DC

49CFR38—Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles

4.2.7 State of Texas, Texas Department of Public Safety, Austin, TX 78773-0001

Texas Traffic Laws—Current Year

4.2.8 Other Resources

Oberg, E., Jones, F.D., Horton, H.L., Ryffel, H.H., McCauley, C.J. et al (Eds.). (2008). **Machinery's Handbook** (28th ed). New York: Industrial Press.

4.3 General Design Standards

4.3.1 Safety of Operation and Construction

Safety of persons using automotive adaptive equipment and vehicles that have been modified shall be the primary design consideration. Any installation of equipment or modification of the motor vehicle shall not introduce new single-point failures of the associated vehicle subsystem which otherwise did not exist in that subsystem and which compromise user safety, or safety of the motoring public. Any installation of equipment or modification of the motor vehicle shall not unnecessarily compromise crash worthiness provisions provided by the vehicle manufacturer in compliance with the applicable Federal Motor Vehicle Safety Standards, nor present unnecessary hazards, such as sharp edges, to vehicle occupants. Adaptive modification of a motor vehicle shall

not deny persons with a disability essential vehicle functions which are otherwise available on the OEM vehicle. The design of the adaptive equipment itself shall meet the applicable standards set forth below in these Standards.

4.3.1.1 Workmanship

Workmanship of any adaptive equipment and its installation in a motor vehicle shall be comparable to the best commercial practice. Where applicable, all installations shall be designed to be permanent, and shall use hardware, fastenings, and connectors consistent with permanent installation.

4.3.1.2 Cost Effectiveness

TWC VRD is committed to assisting the greatest number of customers within the fiscal limits of its spending authority to achieve the written plan for each customer which has been developed for their employment or independent living needs. Where vehicle adaptation requirements can be met by suitable alternative approaches which meet these standards, the least costly approach will be purchased.

4.3.2 Conventional Use

As a general design principle, all adaptive equipment and vehicle modifications should permit operation and use by drivers and passengers other than those for whom the vehicle adaptation is designed, with as little change as possible from conventional subsystems operation and function.

4.3.3 Mechanical and Assembly Design Requirements

4.3.3.1 Mechanical Design Requirements

Design of automotive adaptive equipment shall be consistent with accepted engineering principles and with automotive design practice with regard to materials, structures, lubricants, and maintainability. Any adaptive device or component shall be designed to enhance the usability of the vehicle by the person with a disability, and should not unnecessarily decrease the vehicle's value, safety of operation, service life, or cost of operation.

Automotive adaptive devices shall be designed and constructed to be compatible with the automotive environment. The design and construction of adaptive devices shall prevent permanent deformation or failure under the stress of normal usage as specified by the manufacturer and to operate reliably over an extended period of time comparable to the depreciable service life of the vehicle in which the device is installed.

4.3.3.2 Assembly Requirements

Assembly of automotive adaptive equipment shall have workmanship in accordance with good commercial practice and shall conform to the following specific requirements:

4.3.3.2.1 Mechanical and Assembly Weldments

The design and fabrication of any weldments shall conform to the American Welding Society Structural Welding Code, D1.1 most recent revision, for steel construction, or to the AWS Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe, D10.7, most recent revision, as applicable.

Certified welders shall perform all welding. These welders are to be licensed by their state, and/or in possession of their American Welding Society D1.1 or D1.3 certification qualifications.

4.3.3.2.2 Mechanical and Assembly Fasteners

All fasteners used shall conform to the SAE Standards or Recommended Practices as applicable. All fasteners used shall be designed or treated for resistance to loosening from vibration.

4.3.4 Electrical and Electronic Design Guidelines

4.3.4.1 General

Any electrical or electronic component of an automotive adaptive device shall be designed, assembled, and connected in a manner suitable for the automotive operational environment: temperature extremes, vibration, mechanical shock, dust and dirt contamination, electromagnetic and electrostatic interference, salt spray, water and other chemicals, especially hydrocarbons.

4.3.4.2 Electrical Design Requirements

Any electrical component and its associated wiring including connection into or in place of the stock automotive wiring shall meet the minimum standards of SAE J1292.

4.3.4.3 Electronic Design Requirements

As a design goal, all electronic devices should meet SAE J1211 in order to assure safe and reliable performance in automotive equipment.

4.3.4.4 Labeling of Controls and Displays

All labels for controls, operation of equipment, and/or for cautionary information shall be designed to be legible at the distance at which they would be expected to be read under normal operating conditions, under ambient daytime conditions of illumination. All labels

shall be designed to remain permanently affixed and legible for the design lifetime of the device or panel to which they are affixed.

4.3.5 Hydraulic, Pneumatic, and Vacuum Design Guidelines

4.3.5.1 General

Any hydraulic, pneumatic, or vacuum operated subsystem of an automotive adaptive system shall be designed, assembled, and connected in a manner suitable for the automotive operational environment, as defined and applicable in SAE J1211.

4.3.5.2 Hydraulic Design Requirements

Hydraulic components, including pumps (motor driven or engine driven), actuators, valves, fittings, and hoses shall conform to the following SAE standards as applicable:

- SAE J514
- SAE J516
- SAE J517
- SAE J518

Selection and installation of hydraulic hose shall conform to the general guidelines of SAE J-1273. All hoses used for adaptive equipment for power steering systems including servo controls shall meet the requirements of SAE J190.

4.3.5.2.1 Hydraulic System Integrity

All adaptive equipment using hydraulic components shall meet SAE J1273, and in addition shall not leak as defined in SAE J1176.

4.3.5.3 Pneumatic and Vacuum Design Requirements

Pneumatic and vacuum equipment includes actuators, valves, hoses and fittings designed for operation by either compressed air or by engine manifold vacuum. Pneumatic hoses and associated fittings shall meet the requirements of SAE J1402.

Vacuum hoses and associated fittings shall meet the requirements of SAE J1403. All vacuum hoses connected to adaptive equipment shall be secured by suitable hose clamps.

4.3.5.3.1 Pneumatic and Vacuum Integrity

Any audible leak in pneumatic equipment will disqualify that equipment from acceptance. Any vacuum operated adaptive equipment shall be capable of sustaining a vacuum of at least 10 inches of mercury for five minutes with vacuum source not running. Any pneumatically operated adaptive equipment shall not drop more than 5 psi in five minutes with compressed air source not running.

4.3.6 Installation of Automotive Adaptive Equipment

4.3.6.1 General Requirements

The installation of automotive adaptive equipment shall not require alterations of the motor vehicle which unnecessarily impair or reduce any safety features originally designed into the vehicle, and specifically any safety equipment required by Texas Traffic Laws, Chapter 547 Vehicle Equipment. Although it is highly desirable not to deface the vehicle or otherwise reduce its resale value this desire is of secondary importance to assuring the secure installation of any device.

If the modifier or adaptive equipment company adds more than 220 lbs. to a vehicle, they shall notify the customer what the payload capacity of the vehicle is after modifications. This notice shall also include the statement that these calculations do or do not include the weight of the wheelchair and the new payload capacity shall be written on the "Make Inoperative" form.

4.3.6.2 Installing Agency

Where adaptive components or devices are designed to be installed by a dealer, suitable installation instructions shall be provided.

All vehicles for which the make-inoperative exemption is used as a basis for compliance shall have a permanent label affixed to the driver's doorjamb that states:
"This vehicle had been modified in accordance with 49 CFR 595.6 and may no longer comply with all Federal Motor Vehicle Safety Standards in effect at the time of its original manufacture". The label shall include the Modifiers name and street address.

4.3.6.3 Installation Fasteners and Hardware

Design of automotive adaptive equipment installation fasteners and hardware shall be consistent with accepted engineering principles and with automotive design practice with regard to materials, structures, lubricants, and maintainability.

Installation fasteners and hardware shall be compatible with the automotive environment. They shall resist permanent deformation or failure under the stress of normal usage as specified by the manufacturer.

4.3.6.3.1 Mechanical

All fasteners used shall conform to the SAE Standards or Recommended Practices as applicable. All fasteners used shall be designed or treated for resistance to loosening from

vibration. Fasteners shall not protrude from surfaces in such a way that they present a hazard to service personnel or that they might puncture or abrade hoses, cables, or wiring. The construction and materials of mounting hardware shall be such as to resist permanent deformation or failure of the joints under the stress of normal use as specified by the manufacturer. All fasteners and hardware required for installation in a particular motor vehicle shall accompany the device.

4.3.6.3.2 Electrical

All electrical connections with adaptive equipment shall be in accordance with the installation instructions of the manufacturer of the equipment. Wire terminals (lugs, connecting contacts, binding posts, etc.) shall be properly sized for the required wire and/or connecting devices. Cables, individual wires, and other electrical or electronic hardware shall be assembled, supported, and secured in accordance with SAE J1292.

4.3.6.4 Installation of Automotive Adaptive Equipment Weldments

Any installation of adaptive equipment that requires weldments shall comply with the requirements of 4.3.3.2.1

4.3.6.5 Installer/Modifier Requirements

The installation, adjustment, maintenance, and repair of all adaptive equipment and associated vehicle modifications purchased by the TWC VRD shall be accomplished by authorized dealers for that equipment. Each installer/modifier shall carry a minimum of $1,000,000 per occurrence garage liability, including products and completed operations liability, and sufficient garage keeper's insurance to adequately cover the total value of all vehicles which can be located at their premises at one time.

For those installer/modifiers who cannot procure garage liability insurance, commercial general liability and business auto insurance covering non-owned vehicles must be carried. The general liability policy shall include products and completed operations liability and shall be written on an occurrence form. The requirement for garage keeper's insurance remains as previously stated.

A certificate of insurance (ACORD or other equivalent form containing the same information), detailing coverage as described above, and signed by the agent, shall serve as proof of coverage and shall be submitted to the TWC VRD.

The certificate shall include a statement that products and completed operations liability coverage is included in the policy. Addendums, changes, and updates of renewal date on these insurance policies shall be sent to the TWC VRD as soon as possible after implementation.

4.3.7 Usability and Maintainability

4.3.7.1 Usability and Maintainability General Requirements

TWC VRD's goal is to provide simple, cost-effective, and reliable adaptive equipment. Awkward, needlessly complicated, or makeshift equipment has no place in this program, and will not be purchased by the TWC VRD. The design of all automotive adaptive equipment shall conform to generally accepted human factors principles of operation, as well as to anthropometric and force limitations (modified as required for the customer being adapted) as contained in standard human factors (ergonomic) sources such as MIL-ASTD-1472F.

Almost all equipment requires maintenance. TWC VRD’s goal is to provide adaptive equipment that has provisions for making periodic maintenance as simple, inexpensive, and quick as possible consistent with cost effectiveness. TWC VRD customer shall be provided with a schedule of recommended maintenance. If owner or operator maintenance is recommended, then the manufacturer or modifier shall design and/or install adaptive equipment such that parts requiring such recommended maintenance are readily accessible without major disassembly or the use of special tools.

4.3.7.2 User Information

The manufacturer, supplier or installer shall furnish a user manual with each adaptive device which contains information on the proper use and operation of the device: general operation, operation of all controls, required user actions, actions which the user must not take (hazard warnings), warning of unusual noise, movements, or other fright-producing factors, how to recognize and what to do in case of malfunction, and maintenance information, including schedule and who is to perform the maintenance (e.g., modifier, auto repair shop, owner representative).

4.3.7.3 Maintenance Information

The manufacturer of adaptive equipment shall specify if there is any user/owner maintenance to be performed, provide as part of the user instructions sufficient information to permit the user/owner to perform the maintenance operations, and identify those periodic or non-periodic maintenance operations (if any) which must or should be performed by the manufacturer, supplier or installer. This user/owner maintenance information shall include a parts list with instructions on how to obtain spare parts or replacements. The maintenance information shall include sufficient information to assure economical maintenance and repair of adaptive devices. This information shall include names and location information on the manufacturer or their representatives.

4.3.8 Quality and Warranties

4.3.8.1 Quality

In view of the seriousness of in-service failures, quality control assurances are the responsibility of the manufacturers of adaptive equipment commercially sold. Evidence

of such assurances can be in the form of a seal, inspection stamp, tag, or any other legible identification. In order to permit parts traceability, each device that constitutes a separate subsystem shall bear a model number, a serial number, and the manufacturer's name and location.

The responsibility of product safety, reliability, and liability rests with the manufacturer of every adaptive device. Although devices may be accepted for purchase by the TWC VRD under the requirements of these Standards, TWC VRD assumes no liability for any claim arising from the use of such devices. Any tests which may be required by the TWC VRD to demonstrate quality, durability, usability, safety or other design requirements will be undertaken by the manufacturer, distributor or installer at their own expense.

4.3.8.2 Warranties

The minimum warranty period for both labor and parts for any automotive adaptive equipment or vehicle modification shall be specified by the manufacturer, but not less than one year from date of acceptance by the TWC VRD or final delivery to the customer, whichever is later.

A statement of warranty shall be provided with each adaptive device assuring the quality of materials and workmanship of the product that specifies exact coverage, period of warranty, and recourses. The warranty shall state that if defects are found during the warranty period, the device will be repaired, replaced, or a refund made by the modifier or their authorized agent. An equivalent statement of warranty shall be provided by the installer of adaptive equipment. The modifier shall assume primary responsibility for the workmanship of the modification, and for all equipment installed and work done for the modification, including that accomplished by any subcontractors. The modifier shall ensure that warranties provided by manufacturers and subcontractors are included in the documentation provided to the TWC VRD customer at the time of delivery, and that such warranties and owner registrations are properly filled out. The warranty statement from the vehicle modifier or installer must be in writing.

4.3.8.3 Recalls and Updates

The installer or modifier shall obtain and maintain adequate information on how to contact the TWC VRD customer in the event that a device or modification has been recalled or requires updating for safety reasons. It should be noted that at that point in time the person for whom the modification was performed may no longer be an active customer of the TWC VRD and thus may be solely responsible for responding appropriately to such recalls and updates.

4.4 Specific Subsystem Standards

The standards contained in this section shall incorporate all the requirements identified in the 4.3 General Design Standards section as applicable. Where standards in the specific

subsystem section exceed or are in conflict with general design standards, the specific subsection standard shall govern.

4.4.1 Primary Controls

- 4.4.1.1 Mechanical Hand Controls
- 4.4.1.2 Assist Devices
- 4.4.1.3 Steering Column and Shaft Extension
- 4.4.1.4 Power Steering Modifications
- 4.4.1.5 Power Brake Modifications
- 4.4.1.6 Left Foot Accelerator and Other Pedal Extension
- 4.4.1.7 Powered Primary Controls

Primary controls are controls for implementing throttle, brake, and steering inputs to the motor vehicle. Any adaptive primary control which does not fit the description of the above controls may be evaluated on a case-by-case basis by the TWC VRD PSART.

4.4.1.1 Mechanical Hand Controls

Mechanical hand controls are those devices that a person with a disability uses to operate the accelerator and service brakes of a vehicle. This subsection is limited to non-powered hand controls manufactured for use by persons with disabilities.

4.4.1.1.1 Mechanical Hand-Controls Design Requirements

All mechanical hand controls shall be certified by the manufacturer to meet SAE J1903 or VAPC-A-7505-8. Mechanical hand controls shall be designed to be permanently installed in a motor vehicle.)

4.4.1.2 Assist Devices

Assist devices are add-on devices for use with automotive steering wheels or other primary controls. They may be permanently attached or may be designed for a quick disconnect for use by drivers who do not need it. Such devices are spinner knobs, C-grip, U-grip, tri-pin, ring-type spinners, pin attachments, foot stirrups, or other designs. These devices are used by drivers who require some assistance in gripping or operating a primary control

4.4.1.2.1 Assist Devices Design Requirements-

All assist devices shall be certified by the manufacturer to meet VAPC-A-7505-8. . Modifiers shall consider potential interference with airbag deployment and hazards introduced by the projecting hardware of the assist device in selecting and locating these devices. Additionally, caution shall be exercised to avoid interference with other controls or objects.

4.4.1.3 Steering Column and Shaft Extension

A steering column extension is any elongation of, addition to, or replacement of an OEM steering column. A steering shaft extension is any similar modification or replacement of the OEM shaft, including provisions for steering with the feet.

4.4.1.3.1 Steering Column and Shaft Extension Design Requirements

Either a steering shaft or column extension or both shall provide accessibility to the driver to control the steering mechanism without requiring increased torque or differences in input requirements other than changing the plane of rotation of the control. The steering column extension shall provide sufficient support of the steering shaft and/or its extension. Preservation of the original function of steering control input and sufficient strength to handle anticipated loads to the steering wheel or any of the steering components shall be maintained. Increased friction, varying amount of resistance to torque input as the wheel is turned, or excessive free play shall not be introduced by a steering column or shaft extension.

Steering column extensions may be complete replacements or add-ons. They shall be of a durable material at least comparable to that used for the OEM column.

4.4.1.3.2 Steering Column and Shaft Extension Safety Provisions

Modifications or extensions should not interfere with the safety provisions of the OEM steering column, nor should an OEM airbag be disconnected or eliminated unless provision of the extension and/or other adaptive equipment precludes airbag retention.

Any chain drive or other drive trains introduced as part of such a conversion shall not introduce an unnecessary hazard to drivers or passengers.

4.4.1.4 Power Steering Modifications

Power steering modifications are any modifications which are made to the OEM power steering system to reduce the effort of steering. These standards are limited to modifications for lowering the amount of driver effort required to operate the steering system, which retain a steering wheel and the OEM mechanical steering systems for steering control, with unchanged steering gearbox ratio, including additional equipment which is installed to provide required redundancy for back-up/emergency operation.

4.4.1.4.1 Power Steering Modifications Design Requirements

All power steering modifications shall be certified by the manufacturer to meet the draft standards of the U. S. Department of Veterans Affairs (VAREC-A-8110-1 DRAFT). All power steering modifications to reduce effort shall include a source of emergency power which automatically takes over when the primary power source fails to provide at least five minutes of operation at the same level of effort as under normal power. The activation of the back-up power source or takeover event shall be announced to the driver

by a red (preferably flashing) indicator and an auditory warning visible and audible to the driver in the environment of a vehicle at speed. The driver shall be provided with an accessible switch to turn on the back-up system in case the automatic back-up system fails.

4.4.1.5 Power Brake Modifications

Power Brake modifications consists of modifications to the OEM power brake system to lower the amount of driver effort required to operate the brakes. These standards are limited to modifications which retain the OEM brake pedal and associated linkage, master cylinder, plumbing, brake wheel cylinders, and additional equipment which is installed to provide redundancy for back-up/ brake operation.

4.4.1.5.1 Braking Modifications Design Requirements

All brake modifications shall be certified by the manufacturer to meet (VAREC A-8209-1 Draft). All power brake modifications shall include a source of power which automatically provides at least 5 full brake applications before brake effort increases over that required during normal operation, and at least 5 more applications before brake effort is double that required during normal operation . The reduced effort brake installation, if vacuum assisted, shall include a low vacuum (below 10 inches of Mercury or as set by the manufacturer) alarm. When the primary reduced effort brake systems ceases to function and the back-up reduced effort brake system engages, an audible and visible alarm shall activate. Alarms shall consist of a visible red (preferably flashing) indicator and an audible alarm capable of being heard by a driver in a vehicle at speed.

4.4.1.6 Left Foot Accelerator and Other Pedal Extensions

Left foot accelerators are devices which enable a driver who has lost function or mobility of their right lower extremity to operate the accelerator pedal with the left foot.

Pedal extensions may be blocks attached to pedal surfaces or levers with pedals or other similar devices designed to bring foot operation of the OEM pedals (accelerator, brake, clutch, or parking brake pedal) within the lower extremity range of motion,

4.4.1.6.1 Left Foot Accelerator Design Requirements

All left foot accelerators shall be designed to fold out of the way, or be readily removable without the use of tools, when the vehicle is driven by another driver. They shall not interfere with the operation of any other control of the vehicle, adaptive or OEM. They shall afford the driver who has a disability a full range of accelerator control from idle to kickdown. The left foot accelerator shall not increase the effort required to operate the accelerator, nor shall such a device stick, or jam the OEM accelerator pedal. Although a left foot accelerator should be sturdy enough to meet 4.3.3 and 4.3.6 above, it should not be so massive as to weigh down the pedal and thus induce inadvertent acceleration. A left foot accelerator shall be designed to prevent inadvertent folding when in use by the driver

for whom it was intended. The left foot accelerator pedal pad surface shall be made of a non-skid material.

4.4.1.6.2 Pedal Extension Design Requirements

Pedal extensions can take many forms, and may be designed to be permanently installed or to be capable of being readily removed. Consistent with 4.3.3 and 4.3.6 above, they shall not interfere with the operation of any OEM or adaptive control of the vehicle. They shall afford the driver who has a disability full travel of the pedal which is being extended, without an increase in effort, unless doing so is for purposes of adaptation. They shall not stick or jam the OEM pedal. A pedal extension shall not be so massive as to weigh down or otherwise inadvertently operate the pedal to which it is attached or associated. The extension pedal pad surface shall be made of a non-skid material.

4.4.1.7 Powered Primary Controls

Powered primary controls are add-on or replacement controls for accelerator, brake or steering (including combinations of any or all of these) which are designed to supplement by power, other than by the driver's own muscular efforts, the force output of the driver. Powered primary controls are required when there is lack of strength, range of motion, and/or loss of functions.

Powered primary controls should be servo controls because provision of a feedback loop renders the behavior of the control system substantially similar to a nonpowered system. They differ only in the amount of effort required to effect a control input, direction, amount of motion, and limb used. Only such a system meets the general requirement of 4.3.7.1. Any powered control which is open loop and depends on the driver, friction, inertia, vehicle dynamics or any other indirect means to limit or modify control system output in order to achieve the control setting desired by the driver is not a servo control. The TWC VRD PSART must evaluate these controls on a case-by-case basis. Powered primary controls are controls other than those covered under 4.4.1.1, 4.4.1.2, 4.4.1.4, 4.4.1.5, and 4.4.1.6.

An acceptance test for any powered primary control may be required by the TWC VRD. TWC VRD PSART is the final judge as to acceptability of the test procedures and results (See Paragraph 4.1.1).

Powered primary controls should be installed only when prescribed by a certified driver rehabilitation specialist. The end user shall receive training by the certified driver specialist using the equipment installed.

4.4.1.7.1 Warranty

Powered primary controls shall have a parts and labor warranty period of 5 years, 2,500 hours of operation, or 60,000 miles whichever comes first from the date of delivery to the original customer.

4.4.1.7.1 Powered Primary Controls Design Requirements (General)

Control Type—A powered primary control shall be a position (zero-order) control system. Power source, feedback loop (if used), and activation can be accomplished in a variety of ways: hydraulic, pneumatic, vacuum, electrical, electronic, mechanical, or combinations of any of these. A powered primary control may be combined with a mechanical linkage or hand control.

Back-up Provisions—All powered primary controls shall incorporate into the modification a redundant back-up power capability. The back-up power for the control shall be isolated from the primary system through some means, thus assuring that failure of the primary system power source will not cause a failure of the back-up system. Such back-up power provisions shall be sufficient for at least five minutes of undegraded operation.

If the primary power source for the powered primary control fails, the back-up power source shall automatically take over without additional control by the driver. Activation of the back-up power source shall be announced to the driver in the form of a red (preferably flashing) indicator and an auditory warning visible and audible to the driver, in the environment of a vehicle at speed.

Electromagnetic Interference—The manufacturer shall make provision for shielding and protection of electronic components producing or being affected by electromagnetic interference (EMI). The manufacturer shall have available documentation as to what provisions have been made to avoid EMI, a statement about their effectiveness, and explicit instructions to the installer for shielding and other provisions for avoiding EMI.

Alterations or Effects on Vehicle—Consistent with the goal of successfully adapting the vehicle for the intended customer, installation of a powered primary control should not require alterations to the vehicle which diminish the structural integrity of vehicle components, or degrade the quality, handling characteristics, outward visibility, reliability, and efficiency. The installation should not require the removal or disabling of any safety features or occupant protection devices built into the OEM vehicle.

Operation by Other Drivers—Powered primary controls should not impede or defeat the control of the vehicle by another driver using the OEM controls, nor require that the OEM controls be removed (although they may require a mode change to become operative). A means should be provided to prevent inadvertent operation of the powered primary control when the vehicle is driven by other drivers. Such shutoff devices should be designed so they cannot be inadvertently operated by the driver for whom the control is intended. The shutoff device should also be designed to be operated by that driver if the powered control is left in the shutoff mode by someone else.

Control Characteristics—The ratio (gain) between output from the servo control (which forms the control input to the motor vehicle) and the input from the driver shall not be so high as to induce oscillation or other disturbance to smooth control, nor shall it be so low as to require undue control movement by the driver at any speed from 0 to 80 mph. Gain change with vehicle speed may be used to satisfy the above requirements for gain limits.

Lag or delay in response of the control output to driver input is inherent in any powered control system, however, lag shall be minimized such that vehicle/driver performance with the control is comparable to that obtainable with the unmodified OEM control.

Direction of Motion for Control Input—Control input directionality should follow generally accepted principles of movement and driver expectations as summarized in MIL-STD;1472F unless particular driver movement capabilities and limitations preclude such directions from being used. The manufacturer and installer shall consider the effect vehicle dynamics might have on control input in deciding directionality and location of the control input device. Consideration shall also be given to the past experience the driver may have had with either mechanical primary controls or powered primary controls with regard to directions of motion for control input.

4.4.1.7.2 Powered Accelerator/Brake Control Design Requirements

OEM Accelerator/Brake Systems Left Intact—In addition to the general design provisions of 4.4.1.7.1, powered accelerator/brake controls shall not require modification of the OEM accelerator/brake systems beyond modifying the OEM pedals or pedal arms for attachment purposes. If a powered accelerator/brake control is designed to connect or otherwise be integrated into any OEM electronic units for control of accelerator and/or brake, such a design will be evaluated on a case-by-case basis by the TWC VRD PSART before acceptance by the TWC VRD.

Braking Performance—A powered accelerator/brake control system shall provide braking performance equivalent to the OEM braking system. It shall be capable of exerting a brake pedal force equivalent to 150 lbs. at the pedal over the range of pedal travel (including the partial brake failure travel described in FMVSS 105) expected for the vehicle specified by the manufacturer as suitable for installation of the powered accelerator/brake control system. Lag or delay between onset of driver control input and onset of brake application in excess of 0.10 sec is undesirable, and will require further evaluation before a decision on acceptability can be made.

Redundant Back-up Power and Emergency Braking—Automatic back-up power as required in 4.4.7. shall be provided for brake control, and should be provided for accelerator control. In addition, provision shall be made for emergency braking in the event the powered control actuator fails. The activation of the emergency braking shall not require the driver to remove his or her contact with the control.

Maximum Forces to the Vehicle Pedals—The maximum force output of the powered accelerator/brake control on the OEM pedals shall not exceed 300 lbs. to the brake pedal pad (or a proportionally higher force on other portions of the brake pedal arm), and 50

lbs. to the accelerator pedal pad (or a proportionately higher force on other portions of the accelerator pedal arm).

4.4.1.7.3 Powered Steering Controls

Powered steering controls are units which replace or separately power the OEM steering system, but provide a substitute multiple-turn steering wheel input device placed within the driver's reach envelope, level of input strength, and control operation capability. "Joystick" or lever-type steering adaptations are specifically excluded from this definition of powered steering controls. Power steering controls shall meet all the requirements of 4.4.7.2, as applicable. In addition, the following design requirements apply to powered steering controls.

Gain of Powered Steering Control—The number of turns, lock-to-lock, shall be not less than 2 or more than 8, without special review by the TWC VRD PSART prior to acceptance.

Control Type—The powered steering control is a unit for positioning the otherwise unaltered OEM steering system of the motor vehicle. Although a given excursion of the adaptive steering wheel need not be 1:1 with the resulting motion of the OEM steering wheel (if retained), it shall retain a consistent (unchanging) relationship throughout the range of motion. This is a position type (zero-order) control.

4.4.1.7.4 Joystick Powered Steering Control

A joystick powered steering control is a high-gain steering positioning (zero-order) adaptation suitable for drivers with disabilities that preclude use of a multiple-turn steering wheel, whether reduced effort power steering or a powered steering control as described in 4.4.1.7.3. A joystick steering control may be combined with a accelerator/brake powered control (4.4.1.7.2) or it may be for steering only. The entire excursion of the front wheels lock-to-lock is accomplished (at low speeds) by a control input of typically +/- 45 degrees from neutral. As applicable, a joystick powered steering control shall meet all the requirements of 4.4.1.7.1, and in addition shall incorporate the following performance characteristics.

Control Characteristics—The gain (ratio between joystick control movement and resultant movement of the front wheels) between output from the joystick control (which forms the control input to the motor vehicle) and the input from the driver shall not be so high as to induce oscillation or other disturbance to smooth control, nor shall it be so low as to require undue control movement by the driver at any speed from 0 to 80 mph.

Lag or delay in response of the control output to driver input is inherent in any powered control system, however, lag shall be minimized such that vehicle/driver performance with the control is comparable to that obtainable with the unmodified OEM control.

Gain Attenuation Required—A joystick steering control shall incorporate provisions for reducing gain as the vehicle speed increases. Without such provision, any motor

vehicle becomes unstable at speeds even as low as 20 MPH, because a very small steering input creates an unacceptably high amount of lateral acceleration (yaw). At the same time, sufficient control must be present to permit the driver to make an evasive maneuver, such as a sudden lane change, to avoid an accident situation.

Directions of Control Movement—A left movement of the joystick shall command a steering maneuver to the left, a right movement of the joystick shall command a steering maneuver to the right. When combined with accelerator/brake controls, a joystick steering control should emulate the motion conventions of a power wheelchair: accelerator - forward, brake - rearward.

These control directions are consistent with MIL-STD-1472F, but user prior experience and needs may make other control directions preferable to those recommended here. The driver evaluator and the vehicle modifier shall carefully consider vehicle dynamics in configuring this control system, especially the control interface with the driver, to minimize possible coupling of such dynamics with control inputs.

Conventional Steering Capability—A joystick powered steering control shall incorporate a method of permitting emergency driving by another person, such as a service technician. A joystick primary control is completely unlike the conventional control system of a motor vehicle, and requires considerable training in its use to safely drive it in traffic. Such training could not be expected of service personnel, or even an attendant of a driver for whom the joystick is furnished. If not suitable for such a conventional steering capability, then a warning placard shall be affixed to a conspicuous location within a driver's range of vision. Suggested wording is:

"Warning Joystick Steering Installed Do Not Drive Unless You Are Trained"

4.4.2 Secondary Controls

- 4.4.2.1 Secondary Controls General Design Requirements
- 4.4.2.2 Secondary Control Panels
- 4.4.2.3 Transmission
- 4.4.2.4 Turn Signals
- 4.4.2.5 Hazard Warning Signals
- 4.4.2.6 Windshield Wiper/Washer
- 4.4.2.7 Ignition and Engine Start
- 4.4.2.8 Lights
- 4.4.2.9 Seat Adjustment
- 4.4.2.10 Power Windows
- 4.4.2.11 Heating, Ventilation, and Air Conditioning (HVAC) Controls
- 4.4.2.12 Door Locks
- 4.4.2.13 Parking Brake
- 4.4.2.14 Horn
- 4.4.2.15 Cruise Control
- 4.4.2.16 Mirrors

- 4.4.2.17 Rear Accessories

Secondary controls are any devices that accept a control input from a driver for the purpose of operating the subsystems of the motor vehicle, other than those associated with the primary control of steering, accelerator (velocity command), and brake. The classification of secondary controls is not indicative of a lack of importance or safety.

There are three classes of secondary controls. Mode A controls are controls that must be accessible to the driver while maintaining control of vehicle steering, accelerator, and brake with the vehicle in motion. Mode B controls are those which are accessible to the driver maintaining control of the brake function, while the vehicle is not in motion. Mode C controls are any secondary controls not classified as Mode A or Mode B. Mode C controls are those accessible to the driver when the vehicle is stationary, i.e., parked or not in the traffic stream. If desired and feasible, Mode B or C controls may be upgraded to Mode B or Mode A, but controls shall not be downgraded from their classification herein.

Mode A Controls

- Cruise Control "Set"
- Headlamp Beam Selector
- Horn
- Turn Signals
- Windshield Washer/Momentary Wipe

Mode B Controls

- Transmission
- HVAC
- Exterior Lamps
- Windshield Wipers
- Parking Brake

Mode C Controls

- Ignition And Engine Start
- Seat Controls
- Power Windows
- Door Locks
- Cruise Control "On"
- Hazard Flashers
- Interior Lamps
- Mirrors
- Rear Accessories

These standards are limited to adaptive extensions, relocations of controls to a position within reach of a driver with a disability, or to devices which accept an input from a driver and translate that input into an actuation of one of the subsystems identified above. The input must be by means of movements of a member or members of the driver's body, or by voice command. Secondary controls that are excluded from general acceptance under this paragraph may be accepted on a case-by-case basis after an engineering study and acceptance by TWC VRD PSART.

4.4.2.1 Secondary Controls General Design Requirements

The purpose of any secondary control adaptation is to restore effective use of the motor vehicle operating systems to a driver with a disability, so that he or she may drive and operate that motor vehicle in a similar manner and with the same degree of safety as a driver who is capable of using OEM controls. Thus secondary control system adaptive equipment shall be:

- accessible to the driver for whom they are designed when he or she is behind the wheel (exception is remote ignition and engine start control, 4.4.2.7.4);
- not susceptible to inadvertent operation which may be inconvenient or dangerous for the driver and the motoring public;
- suitable for use by other drivers who may have a need to operate the motor vehicle, unless OEM functions are retained;
- provide positive indication of adapted secondary control status.

In the general consideration of secondary adaptive control design, the following guidelines shall be used to the maximum extent possible:

- SAE J1138
- SAE J1139
- MIL-STD-1472F, "Prevention of Inadvertent Operation"
- FMVSS 101
- VAPC-A-7505-8

Extensions, clamp-on devices, raised buttons, or other assists that fasten to existing OEM control surfaces such as levers, knobs, switches, or pushbuttons shall be of suitable materials and strength to prevent permanent deformation under the loads expected to be applied under normal usage. The method of attachment shall be designed to prevent loosening or detachment (except as designed) under normal usage, and not to present sharp edges or abrasive surfaces to the driver. Such add-on devices should not impede other drivers.

4.4.2.2 Secondary Control Panels

A secondary control panel contains relocated secondary controls or more advanced design secondary controls, including associated automotive system displays such as a battery status indicator, door open indicators or warning lamps, shift quadrant indicators,

or display formats presented by electronic devices. The purpose of the secondary control panel is to provide a point or surface of access for the driver, and a protective housing for the electronic components.

4.4.2.2.1 Secondary Control Panel Design Requirements

The secondary control panel shall be designed to provide positive retention of all controls and displays mounted in or on it through use of materials suitable for an automotive environment and of sufficient strength and rigidity to be comparable to OEM panels for the same purpose on the unmodified vehicle.

The secondary control panel shall be designed to pose no unnecessary hazard to vehicle driver or other occupants in the event of a collision, with specific provisions for padding of surfaces likely to be contacted by occupants who are properly restrained, avoidance of sharp edges through suitable protection or rounding to a radius of 0.5 inch, and supports that are designed to yield, deform, or break away under collision-level loading as defined in FMVSS 201.

4.4.2.2.2 Secondary Control Panels Design Requirements for Maintainability

A secondary control panel shall be designed to protect the components that it houses from the interior environmental extremes of the vehicle, inadvertent contact by vehicle occupants, or contamination. However, provisions shall be made for access to serviceable components mounted in or on the panel without requirement for special tools, skills, or methods for gaining access. Any hazards to service personnel or to the equipment which can come about because access to the panel is provided shall be prominently labeled by an appropriately worded label when the access hatch or cover is removed.

4.4.2.2.3 Secondary Control Panel Labeling of Controls and Displays

Panel labeling shall meet the requirements of 4.3.4.4 in its entirety, and FMVSS 101 as applicable, especially nomenclature and/or symbols for the various controls. Illumination of labels may be accomplished by general flood lighting of the control panel, provided such lighting does not present a source of glare to the driver or significantly affect his or her dark adaptation. All illumination sources should include provisions for varying the level of illumination.

Under nighttime levels of illumination, certain labels are required to be illuminated as in FMVSS 101 if they are on the dash panel. These controls if relocated to a panel visible to the driver in the driver position shall be illuminated. Such illumination shall be accomplished for visibility at night without glare. These functions are:

- Hazard Warning
- Wipers
- Washers
- HVAC
- Windshield Defrost

- Rear Window Defrost
- Transmission Position

Label nomenclature and symbols shall be designed to meet the standards of FMVSS 101, unless OEM labels differ, in which case the OEM label for the same function shall be repeated.

4.4.2.2.4 Secondary Control Menuing or Voice Recognition Systems

Secondary control selection and operation may be accomplished by auditory or visually displayed systems that present a menu for the driver to designate the desired control function. Secondary control selection and operation may also be accomplished by voice recognition systems. Modifiers shall provide a suitable means (including OEM) to select and control each such function operated by a menuing or voice recognition system in the event such a system malfunctions. If a menuing or voice recognition system is provided, a function list readable by the driver shall be furnished and affixed in the driver compartment to familiarize the driver with the system. The list may be designed for removal when the driver has learned the system.

4.4.2.3 Transmission

Any adaptation of a transmission selector shall render it capable of at least Mode B operation.

4.4.2.3.1 Transmission Extension Levers

Extension levers shall permit all ranges of the transmission to be selectable by the driver, and shall not interfere with other controls or adaptive equipment.

4.4.2.3.2 Transmission Controls

A transmission control is a device that either replaces or is connected to the automatic transmission control linkage in a manner other than an extension lever. The power input may be mechanical, hydraulic, electric, pneumatic, or any combination of these.

Any ignition interlocks shall not be defeated by the control design or installation. The transmission control shall incorporate a positive indication of transmission position, visible at night, in cases in which the OEM shift quadrant is obscured or removed.

A transmission control shall be designed and positioned such that the possibility of inadvertent operation is minimized. Menuing or voice recognition systems shall not be used to control transmission operation.

All transmission controls shall meet FMVSS 102 as applicable.

4.4.2.4 Turn Signals

Any adaptation of a turn signal shall render it capable of Mode A operation.

4.4.2.4.1 Turn Signal Levers Extension

A turn signal extension shall be designed and installed such as to not prevent the self-canceling feature of the OEM signaling system.

4.4.2.4.2 Turn Signal Controls

A turn signal control is a device that either replaces or is wired in parallel with the standard switching system for operating turn signals. A turn signal control shall incorporate or leave intact the following provisions:

- Positive indication that the turn signals are operating
- Visible indication of the direction of turn
- Automatic cancellation of the signal either by reverse turn of the steering system as on the OEM installation or by an automatic timeout circuit within 20-30 seconds after the brakes are released
- Indication of signal lamp or other failures

4.4.2.5 Hazard Warning Signals

Any adaptation of a hazard warning signal shall render it capable of at least Mode C operation.

4.4.2.5.1 Hazard Warning Extension

An add-on extension, button, or lanyard installed on the OEM hazard-warning switch, usually located on the steering column, shall be so designed that shutoff of the hazard warning should be possible under the same conditions of operation.

4.4.2.5.2 Hazard Warning Controls

A hazard warning control is a device which either replaces or is wired in parallel with the standard switching system for operating the hazard-warning flashers. A hazard warning control shall incorporate or leave intact the following provisions (FMVSS 108):

- Positive indication that the hazard flashers are operating
- Indication of signal lamp or other failures
- Operation with ignition on or off

4.4.2.6 Windshield Wiper/Washer

Any adaptation of a windshield wiper/washer shall render washer capable of Mode A operation and other wiper functions of at least Mode B operation. All extensions to the windshield wiper/washer control shall meet FMVSS 104 as applicable..

4.4.2.6.1 Windshield-Wiper/Washer Control Extension

No specific requirements over 4.4.2.1

4.4.2.6.2 Windshield-Wiper/Washer Controls

A windshield wiper/washer control is a device which either replaces or is wired in parallel with the standard switching system for operating the windshield wipers and washers. A windshield wiper/washer control shall incorporate or leave intact the following provisions:

- All wiper speeds originally available with the unaltered windshield wiper system
- Automatic parking of the wiper arms when the wiper system is shut off and ignition is on

4.4.2.7 Ignition and Engine Start

Any adaptation of ignition and engine start controls shall render them capable of at least Mode C operation.

4.4.2.7.1 Ignition/Engine Start Extension

This is an add-on extension to the OEM bezel that operates the ignition and the engine start function where an adaptive key holder is not appropriate for the driver. Express provisions to minimize the possibility of inadvertent operation (particularly ignition shut off) shall be incorporated in the design and installation of an add-on extension.

4.4.2.7.2 Ignition/Engine Start Controls

Ignition/engine start controls are designed for use by a driver with a disability which either replace or are wired in parallel with the standard switching system. The ignition control and engine start control may be integrated as they are in almost all motor vehicles but they may also be separate controls if they are designed so as to be accessible and/or operable by the driver. An ignition control shall incorporate the following provisions:

- An inadvertent operation, particularly one which shuts off the ignition, shall be minimized by isolating or guarding the switch or control or otherwise making provisions such that although it is still accessible to the driver, it is not likely to be operated through mistake or accident. There are a number of methods for physically or functionally isolating or guarding a switch in sources such as MIL-STD-1472F.
- The OEM provision to disconnect ignition controlled load from the battery during engine cranking.

As a design goal, the ignition switch should retain provisions for theft protection.

An Engine Start control shall incorporate or leave intact the following provisions:

- Interlock with transmission position such that engine cranking is only possible in **PARK** or **NEUTRAL**
- The OEM provision to disconnect ignition controlled load from the battery during engine cranking

Menuing or voice recognition systems shall not be used to control ignition or engine start.

4.4.2.7.4 Ignition and Start Controls (Remote)

A remote ignition and start control shall meet all of the applicable requirements of 4.4.2.7.2. The remote control shall incorporate encoding strategies such as to minimize inadvertent operation of the system by electromagnetic interference, e.g., transmissions from mobile telephones, CB's, garage door openers, or model airplane controllers.

4.4.2.8 Lights

Any adaptation of light controls shall render headlight beam selection capable of Mode A operation, exterior lights of at least Mode B operation, and interior lights of at least Mode C operation.

4.4.2.8.1 Panel and Exterior Light Control

4.4.2.8.1.1 Light Control Extension

An add-on extension handle or lever for a light switch may be a clamp-on or bolt-on device, or it may completely replace the OEM light switch knob or lever.

4.4.2.8.1.2 Light Controls

Light controls are devices which either replace or are wired in parallel with the standard switching system. Although panel lights and exterior lights are generally on the same switch assembly, these functions may be separate switches. If panel light brightness control was part of the OEM design of the panel lighting circuit, provision for adjusting brightness of the panel lights should be incorporated in the design of the light control.

Since adaptive light controls are provided for drivers with a significant disability for whom a discharged battery could pose a significant hazard, a warning device to alert the driver that the headlights are on when the vehicle door is opened shall be provided as part of this adaptive equipment.

Nothing in this section shall be construed to apply to OEM devices for automatic or semi-automatic control of any of the lighting systems of the motor vehicle.

4.4.2.8.2 Headlight Beam Selector

This device is often referred to as a "dimmer switch" or "dip switch", and is designed to accomplish the function of selecting the upper and the lower beam headlights as a Mode A control.

All beam selectors shall retain the OEM indicator or substitute an equivalent high beam indicator.

4.4.2.9 Seat Adjustment

Any adaptation of seat controls shall render them capable of at least Mode C operation.

Adaptive devices for seat adjustment range from simple add-on levers to existing manual releases on motor vehicle seats to control panels for power seats. These devices have the common purpose of bringing seat adjustment controls of whatever kind within reach of the driver with a disability and suitable for the direction and level of strength that he or she may have.

4.4.2.9.1 Seat Adjustment (Manual Extension Levers)

An add-on extension handle or grip to assist a driver with a disability to release a seat for manual adjustment may be a clamp-on or bolt on device, or may be a lanyard or similar device. The device shall be designed such that it does not interfere with either primary or secondary control functions, nor present a hazard to the vehicle occupants in the event of a collision.

4.4.2.9.2 Power Seat Controls

A power seat control may be an OEM power seat control panel which is placed in a location more accessible for a driver with a disability, or the panel may be designed to control a special adaptive seat. The panel shall be designed and installed in such a manner that it does not interfere with operation of either primary or secondary controls, and that the probability of inadvertent operation of the seat is prevented when the vehicle is in motion. In the case of a powered seat which facilitates transfer of the driver from a wheelchair to the driver position, a control panel shall be located at the point of transfer and be accessible to the driver at any point during transfer.

4.4.2.10 Power Windows

Any adaptation of window controls shall render them capable of at least Mode C operation.

Power windows for after-market adaptation of motor vehicles are devices which are sold by accessory manufacturers to replace manual window cranks for those who cannot operate manual windows. The standards in this section do not apply to power window units which are manufactured by or for the vehicle maker for installation as a factory or dealer option, and which are retrofitted by a vehicle modifier, provided the unit is

installed as designed by the vehicle manufacturer and controls are in the locations originally designed by the vehicle manufacturer.

4.4.2.10.1 Power Window Controls.

The arrangement of controls, whether toggle, rocker, or pushbutton shall be consistent with driver expectancies as set forth in MIL-STD-1472F. .

4.4.2.10.2 Power Window Units

Aftermarket power window unit design shall be such as to preclude binding or loss of engagement between the power unit and the split shaft of the original manual window crank. Power window units shall not interfere with seating, operation of any primary or secondary control, or with ingress or egress of the vehicle. Wiring bundles to power window units shall be secured to the door panel or housed within the door panel. Wire bundles that bridge the gap between the door and the adjacent vehicle structure shall be housed in flexible rubber or plastic boots to prevent chafe or pinching of the bundle, or otherwise protected from such damage during opening and closing of the vehicle door. All holes through which wires are routed shall be protected by grommets.

4.4.2.11 Heating, Ventilation, and Air Conditioning (HVAC) Controls

Any adaptation of HVAC controls shall render HVAC control capable of at least Mode B operation.

This class of secondary controls refers to adaptive equipment to permit operation of selected functions or all functions built into a motor vehicle HVAC system. Nothing in this Standard shall be construed to require any motor vehicle to be equipped with any HVAC system or part thereof.

4.4.2.11.1 HVAC Extension Handles

Extension handles attached to HVAC controls shall be designed to permit the driver to use the full range of each control that is adapted.

4.4.2.11.2 HVAC Controls

HVAC controls are devices that either replace or remotely operate the OEM controls, or are wired/connected in parallel with the OEM HVAC control panel. Movement of controls should either follow the movements of the original panel, or should be designed in accordance with SAE J1139. All states of operation that were originally controlled should be available in the adapted control, e.g., if three fan speeds were available on the original control panel, three speeds should be selectable with the adapted control.

4.4.2.12 Door Locks

Any adaptation of door lock controls shall render them capable of at least Mode C operation.

Locks as secondary controls include extensions or modifications to the manual door locks to make them accessible and controllable from the driver's position, and controls for operating power door locks.

4.4.2.12.1 Door Locks (Manual Extensions)

No specific requirements other than 4.4.2.1 above.

4.4.2.12.2 Power Door Lock Controls

A power door lock control is a device which either replaces or is wired in parallel with the standard switching system for operating (a) all the door locks (b) any particular door lock.

If push buttons, membrane switches, or menuing/voice recognition systems are provided, positive indication of lock position shall be provided, e.g., door lock button or status indicator visible to the driver.

4.4.2.13 Parking Brake

Any adaptation of parking brake controls shall render them capable of at least Mode B operation.

Parking brakes as secondary controls include extensions to bring release handles within reach, to render foot operated parking brakes operable by hand, and remotely controlled actuators which apply and release parking brake.

4.4.2.13.1 Parking Brake (Extensions)

An add-on extension to the OEM parking brake may be a clamp-on or bolt-on device, or it may be a device which replaces part of the OEM controls to make applying or releasing (or both) the parking brake more accessible or less effort for the driver with a disability when that driver is in the driver position. Positive retention of the extension or replacement device shall be a primary concern to the modifier, since failure of the extension or replacement device could lead to inability to apply the brake under emergency conditions, or inability to release the brake in order to drive.

4.4.2.13.2 Parking Brake Control

A parking brake control is a device which permits the OEM parking brake to be operated remotely by the driver, or which replaces part or all of the actuating mechanism of the parking brake in order to permit the driver to apply or release the parking brake. Such a device shall incorporate or leave intact the following provisions:

- Positive indication that the parking brake is engaged
- Ability to engage or release parking brake independent of engine, transmission, or ignition state
- Limit switches or similar means to prevent either over application of brakes with consequent damage to the linkage or other working parts, or such slackness in the linkage that an effective application of the brake is compromised
- Ability for the driver to continuously control brake application from full release to full lock, and the reverse at least if the ignition is on (for use as an emergency brake).

4.4.2.14 Horn

Any adaptation of a horn control shall render it capable of Mode A operation. A horn control shall be designed such as to not require a separate control motion to terminate the horn operation.

4.4.2.15 Cruise Control

Any adaptation of a cruise control shall render it capable of Mode A operation (set) and Mode C operation (on/off).

Cruise controls may have other operating functions (other than on/off), such as "resume," "coast," or "decelerate," which may also be adapted. If any such functions are adapted, they shall be capable of Mode-A operation.

Cruise control on/off status should be displayed to the driver by means of a suitable indicator.

4.4.2.15.1 Cruise Control Extensions

Since inadvertent operation can lead to a dangerous situation if the driver is not aware of the cruise control takeover, design of an extension shall specifically incorporate provisions for preventing inadvertent operation.

4.4.2.15.2 Cruise Controls

Adaptive cruise controls shall retain all of the safety features of the OEM control, i.e., release of the accelerator control if a braking input is made by the driver, and manual takeover of acceleration over the set speed.

4.4.2.16 Power Mirrors

Any adaptation of a power mirror control shall render it capable of at least Mode C operation.

4.4.2.16.1 Power Mirror Extension

An add-on extension button, handle, or lever for a power mirror control may be a bonded, clamp-on or bolt-on device, or it may completely replace the mirror control button, knob or lever.

4.4.2.16.2 Power Mirror Control

A power-mirror control is a device which either replaces or is wired in parallel with the standard switching system for selecting and positioning the power mirrors. Mirror controls should duplicate the directions of motion with regard to control action provided by the OEM.

4.4.2.17 Rear Accessories

Any adaptation of rear accessory controls shall render them capable of at least Mode C operation. Any adaptive equipment provided to control rear wipers, washers, defrost, HVAC, or other functions such as fuel tank cover release, or trunk release shall meet the general requirements of 4.4.2.1 above.

4.4.3 Access Devices

Access devices are designed to accommodate the independent or aided entry (ingress) and exit (egress) of the adapted or modified vehicle by a person with a disability.

4.4.3.1 Wheelchair Lifts

Wheelchair lifts include a variety of electric powered mechanical and hydraulic systems used to raise or lower a person in a wheeled mobility aid from one level to another. They are classified by location in the vehicle (side or rear), by power transfer method (e.g. hydraulic, electro-mechanical, or others) and by design (platform or rotary). These standards are limited to power lift systems manufactured for use by persons with disabilities or their attendant for installation in a private motor vehicle suitable for such installation (e.g., vans or minivans). A wheelchair lift permits a person with a disability using a wheeled mobility aid, such as a wheelchair, to enter and exit a motor vehicle in or on their mobility aid.

4.4.3.1.1 Wheelchair Lifts Design Requirements

Wheelchair lifts purchased by the TWC VRD shall be certified by their manufacturer or supplier to meet SAE J2092, J2093, and FMVSS 403, 404 In addition, the lift shall be capable of being returned to the full lowered position if any interlock with the roll stop prevents raising the lift from just above the full lowered position. When on the lift, the independent driver shall be able to operate the lift without using a remote control.

4.4.3.1.2 Accelerated Life Cycle Testing of Wheelchair Lifts

A life cycle test of a wheelchair lift mechanism shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the lift. Half of the cycles shall be performed at the rated load capacity and half of the cycles unloaded. Ambient temperatures shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the lift shall be made at intervals of 500 cycles, and changes in alignment, component wear, loosening of fasteners, and similar conditions shall be recorded. Failure mode analyses of such conditions shall be performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the lift mechanism shall be documented in a written report prepared by the test facility and submitted to the TWC VRD PSART. Any failure of the wheelchair lift that requires replacement or repair of a part to complete the life cycle test disqualifies the lift from complying with TWC VRD Standards.

4.4.3.1.3 Wheelchair Lift Structural Requirements

A lift shall be capable of meeting the structural requirements of ADA. Any ramp 30 inches or longer shall support a load of 600 lbs placed at the centroid of the ramp, distributed over an area 26 inches by 26 inches, without permanent deformation. Such ramp shall also withstand an ultimate load of 1800 lbs without structural failure (safety factor of 3).

Any ramp less than 30 inches in length shall support a load of 300 lbs placed at the centroid of the ramp, distributed over an area 26 inches by 26 inches, without permanent deformation. Such ramp shall also withstand an ultimate load of 900 lbs without structural failure (safety factor of 3).

4.4.3.3 Exterior Access Device Controls

An exterior access device control is any control device which is designed to operate doors, lifts, or power ramps by an independent driver or attendant from outside the vehicle.

They control such operations as:

- lift door open/close
- deploying/stowing of lift platform or ramp

up/down operation of lift platform, ramp, or other adaptive devices

4.4.3.3.1 Exterior Access Device Control Design Requirements

The working end of any control handle or knob inside a box should not be set back more than 1 inch. All controls shall be labeled as to function, order, and direction of use. They shall be mounted inside a lockable enclosure or otherwise secured against unauthorized use. Temporary labels may be affixed to a hidden set of controls (e.g., reed switches hidden in a tail lamp assembly) for guidance to the driver until he or she learns the positions and functions.

All exterior controls shall have provisions for preventing moisture from penetrating into the control units.

4.4.3.3.2 Exterior Access Device Control Installation

Any vehicle body cutout to accommodate an exterior control shall be no larger than required for installation and mounting or as specified in the manufacturer's installation instructions. If holes must be drilled in the vehicle body for passage of wires or hoses to or from an exterior control box, grommets shall be used to prevent damage to wires or cables.

The exterior control shall be accessible by the intended operator under all anticipated conditions.

4.4.3.3.3 Remote Control Design Requirements

Remote controls are devices which control of access device functions or such functions as remote start or door locks by means of wireless electromagnetic radiation (e.g., radio, ultraviolet, or infrared) or by sound waves (usually ultrasonic, i.e., above 15000 Hz). They consist of a transmitter and a receiver that detects and processes the signal for operation of the access devices.

Remote controls shall be designed to be operable by the intended user. When provided, modifiers shall also provide an exterior access device control (4.4.3.3.1) for entry and exit not dependent upon wireless or sound activation in the event of malfunction or loss of the remote control or any of its subsystems. In certain cases, provisions should be made to preclude inadvertent operation when the vehicle is in motion (e.g., small children routinely carried in the vehicle).

4.4.3.4 Automatic Door Openers

Automatic door openers are any powered device which opens and closes vehicle doors to enable access to the vehicle. OEM installed door actuators are excluded from the provisions of this subsection.

4.4.3.4.1 Automatic Door Openers Design Requirements

Automatic door openers shall have a provision to prevent physical damage and door closure when lift or ramp is unfolded or extended. On sliding doors, if a chain or cable is used, the chain or cable should have a guard installed to prevent slap, wear, vehicle

damage, or hazard to vehicle occupants. Where hazard still exists, a placard shall be installed warning of hazard from this device. Automatic lighting shall be installed in conjunction with automatic power doors to illuminate the lowest lift platform position when the automatic doors are opened. Automatic interior lights shall go on when door is opened and shut off when door is closed.

4.4.3.4.2 Accelerated Life Cycle Testing of Automatic Door Openers

A life cycle test of the automatic door opener shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the lift. Ambient temperatures shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the automatic door opener shall be made at intervals of 500 cycles, and changes in alignment, component wear, loosening of fasteners, and similar conditions shall be recorded. Failure mode analyses of such conditions shall be performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the automatic door opener shall be documented in a written report prepared by the test facility and submitted to the TWC VRD PSART. Any failure of the automatic door opener that requires replacement or repair of a part to complete the life cycle test disqualifies the automatic door opener from complying with the TWC VRD Standards.

Mechanisms should be enclosed to the extent feasible to prevent dirt and moisture contamination of working parts and subsequent premature failure. Mechanisms shall be enclosed or guarded if they present a hazard to vehicle occupants while vehicle is in motion.

Where an automatic door opener mechanism substitutes for all or part of the OEM latches, the mechanism shall provide secure closure of the door(s) against their weather seals. Automatic door openers should retain the OEM door latches in order to meet FMVSS 206.

Automatic door openers shall have interior emergency quick-release mechanisms in case of power failure or malfunction. The quick release mechanism will permit opening and closing of doors by another person. A quick release mechanism is not required on cargo door not used for passenger ingress and egress.

4.4.3.4.3 Automatic Door Openers Installation

Automatic door openers shall not compromise the mechanical or structural integrity of the vehicle (the fit between the doors and vehicle body). Doors shall be moisture sealed to prevent water entry in full closed position.

4.4.3.5 Ramps

Ramps are inclined planes that are for the primary purpose of permitting an occupant in a wheeled mobility aid to enter or exit a motor vehicle. Ramps may be permanently installed in or on the sill of a vehicle door and stowed in a retracted position when not in use, or they may be detachable and stored at some location in or on the vehicle when not in use. Ramps may be deployed by mechanical and/or electrical means or may be placed in position by an attendant. Separate tracks or channels are not ramps and will not be accepted.

4.4.3.5.1 Ramp Design Requirements

Ramps designed to be used by a driver (without assistance) shall meet applicable portions of ADA as identified below:

Slope (Unassisted Entry)—Ramps shall have the least slope practicable. If the height of the vehicle floor from which the ramp is deployed is 3 inches or less above the pavement surface on which the vehicle is resting, a maximum slope of 1:4 is acceptable. If the height differential is greater than 3 inches but equal to or less than 6 inches, a maximum slope of 1:6 is acceptable. If the height differential is greater than 6 inches but less than 9 inches, then a slope of 1:8 is acceptable. If the height differential is 9 inches or more, then a slope of 1:12 shall be required.

Slope (Assisted Entry)—Ramps designed to be used with the assistance of an attendant shall not exceed a slope of 1:3.75 or 15 degrees (MIL-STD-1472).

In the event that the slope does not meet the above requirements, the ramp may be accepted if the intended user is able to use the ramp without unreasonable risk. In such cases, a placard visible to a ramp user shall be affixed to the vehicle, warning that the ramp does not meet ADA requirements and may be difficult to traverse. "CAUTION - STEEP RAMP" is suggested wording.

Side Barriers—Any ramp shall incorporate continuous barriers to prevent a wheeled mobility aid from rolling or falling off the side of the ramp. These barriers should be at least 2 inches high measured from the upper surface of the ramp for the effective length of the ramp, i.e., the portion of the deployed ramp extending from the vehicle door to 12 inches from the outer end.

In the event that the side barriers do not meet the above requirements, the ramp may be accepted if the intended user is able to use the ramp without unreasonable risk. In such cases, a placard visible to a ramp user shall be affixed to the vehicle, warning that the ramp does not meet ADA requirements and caution should be exercised traversing the ramp. "CAUTION – LOW SIDE BARRIERS" is suggested wording.

Surface—The ramp surface shall be continuous and finished or covered with a nonskid material. Any openings in the ramp surface(s) shall reject a 0.75 inch ball. The surface shall not have protrusions from the surface greater than 0.25 inch high; ramp (but not

tracks or channels) should have a clear width of 30 inches; and shall accommodate both 4-wheel and 3-wheel mobility aids.

Attachment—When in use for ingress or egress, the ramp shall be firmly attached to the vehicle so that it is not subject to displacement when the user is traversing the ramp, and so that any gap between the vehicle and the ramp does not exceed 0.625 inch.

4.4.3.5.2 Ramp Structural Requirements

A ramp shall be capable of meeting the structural requirements of ADA. Any ramp 30 inches or longer shall support a load of 600 lbs placed at the centroid of the ramp, distributed over an area 26 inches by 26 inches, without permanent deformation. Such ramp shall also withstand an ultimate load of 1800 lbs without structural failure (safety factor of 3). Loads are applied normal to the plane of the deployed ramp.

Any ramp less than 30 inches in length shall support a load of 300 lbs placed at the centroid of the ramp, distributed over an area 26 inches by 26 inches, without permanent deformation. Such ramp shall also withstand an ultimate load of 900 lbs without structural failure (safety factor of 3).

4.4.3.5.3 Accelerated Life Cycle Testing of Powered Ramp Mechanism

A life cycle test of an automatic or semi-automatic powered ramp mechanism shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the ramp. Ambient temperatures shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the ramp shall be made at intervals of 500 cycles, and changes in alignment, component wear, loosening of fasteners, and similar conditions shall be recorded. Failure mode analyses of such conditions shall be performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the ramp mechanism shall be documented in a written report prepared by the test facility and submitted to the TWC VRD PSART. Any failure of the ramp that requires replacement or repair of a part to complete the life cycle test disqualifies the ramp from complying with the TWC VRD Standards.

4.4.3.5.4 Accelerated Life Cycle Testing of Lowering Mechanism

If a vehicle lowering mechanism is offered as part of the ramp installation, a life cycle test of this system shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the lowering mechanism with the vehicle unloaded. Ambient temperature for the test shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the lowering mechanism shall be made at intervals of 500 cycles, and changes in alignment, component, wear, leaks, loosening of fasteners, failure to travel the full extent of motion, and similar conditions shall be recorded. Failure mode analyses of such

conditions shall be performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the lowering mechanism, including a description of any failures and of the condition of the lowering mechanism at the conclusion of the test, shall be documented by a written report prepared by the test facility and submitted to the TWC VRD PSART. Any failure of the lowering mechanism that requires replacement or repair of a part to complete the life cycle test disqualifies the lowering mechanism from complying with the TWC VRD Standards.

The ramp life cycle test and the lowering mechanism life cycle test may be conducted concurrently on the same vehicle.

4.4.3.6 Personal Lift Devices

Personal lift devices are powered units that transport a person who has a disability from street level to the interior of a motor vehicle and return to the surface, but are not wheelchair lifts as defined in 4.4.3.1 or ramps as defined in 4.4.3.5 above, or handling devices as defined in 4.4.4.

4.4.3.6.1 Personal Lift Design Requirements

A personal lift device shall be certified by its manufacturer to be capable of supporting 3 times its maximum rated load without structural failure, and 1.5 times its rated maximum load without permanent deformation. In the event of power failure to the personal lift, the drive mechanism shall lock or be provided with a mechanism to prevent rapid descent with consequent risk to the rider. Controls shall be designed and located so as to be accessible to the intended operator at all levels of travel. Provisions shall be made to minimize the risk of the rider falling from the personal lift. If a personal lift device is provided for an independent driver who cannot otherwise enter or leave the vehicle, then an access battery shall be incorporated in the installation. This is done to minimize the possibility of the driver becoming trapped in the vehicle or suspended at some point between the lowest and highest point of travel.

4.4.3.6.2 Accelerated Life Cycle Testing of Personal Lift Devices

A life cycle test of a personal lift device shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the device. Half of the cycles shall be performed at the rated load capacity and half of the cycles unloaded. Ambient temperatures shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the personal lift shall be made at intervals of 500 cycles, and changes in alignment, component wear, loosening of fasteners, and similar conditions shall be recorded. Failure mode analyses of such conditions shall be performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the personal lift mechanism shall be documented in a written report prepared by the test facility and submitted to the TWC VRD Program Specialist. Any failure of the personal

lift that requires replacement or repair of a part to complete the life cycle test disqualifies the personal lift from complying with the TWC VRD Standards.

4.4.3.7 Steps

Steps shall be provided with a nonskid surface. They shall be affixed to the vehicle to withstand the greater of 1.5 times the weight of the intended user or 300 lbs. of downward load without permanent deformation or separation from the vehicle structure. The addition of steps to a vehicle shall not increase the maximum width of that vehicle (including side mirrors).

4.4.3.8 Assist Handles

Assist handles are hand grips provided for the purpose of aiding a person with a disability in transferring from one location to another. OEM assist handles are not included under this section, but should meet the intent of this section if they are expected to be used by the person with a disability.

4.4.3.8.1 Assist Handles Design Requirements

Handle dimensions shall afford a grip clearance of at least 1 7/8 inches by 4 3/8 inches (inside dimensions) with at least 1 inch diameter grip. Handles of other designs shall meet the bare hand requirements of Figure 4.3-1 for a force of over 40 lbs. Covers of handles shall be rounded to a radius of no less than 0.5 inch, and shall be padded to prevent injury. The grip surface shall be designed to afford maximum hand grip.

4.4.3.8.2 Assist Handles Structural Requirements

Handles shall be designed and installed such that the person with a disability for the intended purpose (e.g., assist in transfer from a wheeled mobility aid to a vehicle seat) without permanent deformation or separation from the vehicle structure, with a safety factor of at least 2.

Figure 4.3-1

4.4.4 Wheeled Mobility Aid Handling Devices

Wheeled mobility aid handling devices are devices for moving a mobility device into or onto a motor vehicle and retaining the mobility aid while in or on the vehicle. Handling devices are classified by their location as either exterior to the vehicle, inside the vehicle but not the passenger compartment, or inside the passenger compartment. Handling devices may be manually operated or may be powered. They may be designed for independent operation, or they may be operated by another person.

Wheeled mobility aid handling devices may perform some or all of the following functions:

- Hoisting or otherwise lifting the mobility aid onto or into the motor vehicle after its user exits the aid
- Retaining the mobility aid on or in the motor vehicle
- Placing the mobility aid within reach of the user after a trip in the motor vehicle is completed.

4.4.4.1 Wheeled Mobility Aid Racks

Racks for carrying scooters or wheelchairs vary from devices similar to bicycle racks suitable for folding manual wheelchairs to powered units capable of picking up and transporting a large scooter. They are mounted at the rear of a motor vehicle.

4.4.4.1.1 Wheeled Mobility Aid Rack Design Requirements

Mobility aid racks shall meet the general design requirements of Section 4.3.3, 4.3.4, and 4.3.5 as applicable, plus the specific requirements identified below.

Loading and Positive Retention—Loading and securing (or release and unloading) shall not require special tools, unusual strength or dexterity, unreasonable disassembly of the mobility aid, nor unreasonable amounts of time.

A rack shall be designed to positively retain the mobility aid for which it is suitable such that the aid will not be released inadvertently in traffic maneuvers or over rough streets or highways, nor induce excessive deformation or wear to the mobility aid. The release mechanism provisions shall be suitable for use by the intended operator. The rack shall not present a safety hazard to the operator or others in any mode of operation.

4.4.4.1.2 Wheeled Mobility Aid Rack Structural Requirements Structural Requirements

Mobility aid racks shall be sturdy and capable of withstanding both dynamic loads likely to be encountered in motor vehicle operation, and suitable for the exterior automotive environment. The factor of safety to be used in their design shall be 3 based on *Machinery's Handbook* guidelines for applications in which reliable materials are to be used under difficult loading and environmental conditions.

4.4.4.1.3 Accelerated Life Cycle Testing of Wheeled Mobility Aid Rack

A life cycle test of a rack shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the device. Half of the cycles shall be performed at the rated load capacity and half of the cycles unloaded. Ambient temperatures shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the rack shall be made at intervals of 500 cycles, and changes in alignment, component wear, loosening of fasteners, and similar conditions shall be recorded. Failure mode analyses of such conditions shall be

performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the rack mechanism shall be documented in a written report prepared by the test facility and submitted to the TWC VRD PSART. Any failure of the rack that requires replacement or repair of a part to complete the life cycle test disqualifies the rack from complying with the TWC DRS Standards.

4.4.4.1.4 Wheeled Mobility Aid Rack Installation Requirements

The installation of a wheeled mobility aid rack shall meet the general requirements of 4.3.6. In addition the installer shall follow manufacturer recommendations for suitable vehicle makes and models. The vehicle manufacturer's maximum tongue weight rating nor the OEM rear axle weight rating shall be exceeded.

4.4.4.2 Wheeled Mobility Aid Hoists

Wheeled mobility aid hoists include any mechanism for loading and unloading an unoccupied mobility aid. They include wheelchair carriers, which are any mechanism for loading and unloading a mobility aid (usually a wheelchair) into and out of a closed container specially designed for this purpose and permanently mounted on the roof of a motor vehicle.

4.4.4.2.1 Wheeled Mobility Aid Hoist Design Requirements

Hoists—Hoists may be levers or arms, or may incorporate flexible cables, belts or chains. Components shall not expose the user to sharp edges or abrasion during any point in the loading or unloading operation. Hooks or other devices for retaining the chair during loading or unloading shall incorporate provisions for avoiding accidental release. The hoist shall be designed for a factor of safety of 2.5 consistent with conditions in which loading and environment are not severe. A hoist shall not present a safety hazard to the operator or others in any mode of operation, nor induce excessive deformation or wear to mobility aid components. A hoist shall meet the requirements of 4.3.3 and 4.3.4 as applicable.

Hooks or other retainment devices shall be designed to be readily engaged and disengaged in a reasonable time by the intended user without the use of tools, or unreasonable disassembly of the mobility aid.

Crashworthiness—A passenger compartment mobility aid hoist shall not compromise crash worthiness provisions of the motor vehicle, nor be located in such a position that the driver of the vehicle or any passenger is likely to strike a structural member of the hoist if they are properly restrained in their seats.

Wheelchair Carrier Enclosures—All wheelchair carriers shall incorporate an enclosure or cover to protect the wheelchair from the elements, and to prevent damage to the chair, when it is in the stowed position. The wheelchair shall be positively secured or restrained at all times by the carrier when the chair is stowed. Wheelchair containers or covers shall be designed to fulfill their function without damage to the chair through excessive contact, sharp edges, vibration damage, moisture, or deformation of the chair.

Pickup Bed Covers—A wheeled mobility aid hoist may be provided with a powered camper top or similar cover. Provision of such a cover shall be considered on a case-by-case basis. Where accepted for purchase, the powered pickup bed cover shall meet the following minimum requirements:

- Tailgate and rear transom shall be accessible and operable to allow another person to be able to get into the pickup bed and release the mobility aid for unloading under emergency conditions
- Cover and associated devices shall meet all the applicable requirements of Section 4.3 and 4.4.4.1.3.
- Raising and lowering mechanism shall positively retain the cover at all times.
- An inter-lock shall be provided so the hoist will not operate until the pickup bed cover is fully raised.

4.4.4.1.3 Accelerated Life Cycle Testing of Wheeled Mobility Aid Hoist

A life cycle test of a hoist shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the device. Half of the cycles shall be performed at the rated load capacity and half of the cycles unloaded. Ambient temperatures shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the hoist shall be made at intervals of 500 cycles, and changes in alignment, component wear, loosening of fasteners, and similar conditions shall be recorded. Failure mode analyses of such conditions shall be performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the hoist mechanism shall be documented in a written report prepared by the test facility and submitted to the TWC VRD PSART. Any failure of the hoist that requires replacement or repair of a part to complete the life cycle test disqualifies the hoist from complying with the TWC VRD Standards.

4.4.4.2.2 Wheeled Mobility Aid Hoist Installation

Hoists—Any mounting holes drilled in the vehicle structure to install the hoist shall be sealed if exterior moisture impinges upon the mounting hardware or fastenings. Electrical wiring shall be routed and/or protected to limit abrasion or interference with any vehicle mechanism, or interference with the driver's ability to ingress or egress the vehicle.

Installation of the hoist in a pickup truck bed shall not interfere with the use or normal operation of the tailgate. Installation of the hoist in a luggage compartment shall not interfere with closure of the luggage compartment.

Exterior controls shall meet the requirements of 4.4.3.3 as applicable. For unassisted users, carrier controls shall be located such as to allow the user to operate the carrier unassisted during all phases of the loading, stowing, and unloading operation.

Carrier Enclosures—The intended load of both enclosure with wheelchair shall not be so heavy as to statically deform the motor vehicle sheet metal on which it is resting in excess of 0.125 inch at any single point of contact. Any penetrations into the passenger or luggage compartment for carrier retention or for electrical cables or similar connections shall be sealed to prevent moisture entering the passenger compartment. Exterior controls shall meet the requirements of 4.4.3.3 as applicable. For unassisted users, carrier controls shall be located such as to allow the user to operate the carrier unassisted during all phases of the loading, stowing, and unloading operation.

Pickup Bed Cover—Installation of pickup bed covers shall meet the requirements of 4. 3.6. Exterior controls shall meet the requirements of 4.4.3.3 as applicable. For unassisted users, carrier controls shall be located as to allow the user to operate the cover unassisted during all phases of the loading, stowing, and unloading operation.

4.4.5 Occupant Protection

4.4.5.1 Seats

Seats as covered herein are limited to vehicle seats which are provided as replacements or supplementary to OEM seats, but are specifically designed for automotive installation. The category of "seat" specifically excludes wheelchairs, whether occupied or not, household or office furniture of any kind, hospital equipment such as beds, cots, or any other non-automotive device. Seats include special adaptive seat assemblies that move a driver with a disability from a wheelchair transfer position to a position behind the controls or to a position suitable for riding as a passenger, and also include seat inserts.

4.4.5.1.1 Seat Design Requirements

Vehicle seats that replace or supplement OEM seats in a motor vehicle shall be specifically designed for automotive use, and further shall meet the requirements of FMVSS 202, 202A, 207 and 302, as applicable. Seats shall either incorporate OEM restraint devices or provisions shall be made for installation of restraint devices which meet the requirements of 4.4.5.2, when the occupant is in the driving or riding position.

Vehicle seats shall have provision for positive locking in position unless their method of adjustment is by means of power actuators as part of a power seat assembly, or transfer assembly, provided that the power train remains positively attached to the movable seat and prohibits back driving (e.g., a worm gear train).

Any cable, wire bundle, or other connective device associated with a vehicle seat shall be designed to remain clear of pinch points, abrasion, or other damage and to remain connected throughout the range of movement of the seat. Individual wires or hoses shall be bundled or secured in a workmanlike manner so as to comprise no more than two bundles for each seat.

Seat inserts shall be constructed of materials suitable for the automotive environment, and shall be capable of positive retention when in use.

4.4.4.1.3 Accelerated Life Cycle Testing of Wheeled Mobility Aid Hoist

A life cycle test of a hoist shall be conducted under the supervision of a registered professional engineer. The life cycle test shall consist of 4400 complete cycles of the device. Half of the cycles shall be performed at the rated load capacity and half of the cycles unloaded. Ambient temperatures shall be recorded. Preventive maintenance shall be performed in accordance with manufacturer's instructions during this life cycle test. Periodic visual inspection without disassembly of the hoist shall be made at intervals of 500 cycles, and changes in alignment, component wear, loosening of fasteners, and similar conditions shall be recorded. Failure mode analyses of such conditions shall be performed and a decision concerning continuation of the test shall be made and documented based on these analyses. The results of the life cycle test of the hoist mechanism shall be documented in a written report prepared by the test facility and submitted to the TWC VRD PSART. Any failure of the hoist that requires replacement or repair of a part to complete the life cycle test disqualifies the hoist from complying with the TWC VRD Standards.

4.4.5.2 Passenger Restraints

4.4.5.2.1 Passenger Restraints Design Requirements

All passenger (including driver) restraints installed as part of an adaptive equipment modification to a motor vehicle shall meet the requirements of FMVSS 209, FMVSS 210, and SAE J383 as applicable to the design of the belt system that is installed. Passenger restraints shall meet these design and installation requirements regardless of the design of seat or other accommodation that may be provided for the driver with a disability or other rider.

4.4.5.2.1.1 Shoulder Restraints

All passenger (including driver) restraint systems installed as a part of an adaptive modification shall provide an upper torso restraint through the use of a shoulder belt or harness regardless of the riding position.

4.4.5.2.1.2 Pelvic Restraints

All restraint systems shall also provide a pelvic restraint through the use of a lap belt regardless of the riding position.

4.4.5.2.1.3 Modified Anchorage Points

Modifiers shall make every effort consistent with 4.4.5.2.2 below to use the OEM occupant protection system with its original anchorage points provided by the vehicle manufacturer. Where such protection systems or anchorage points cannot be used or must be modified to accommodate the customer, alternatives may include use of the wheelchair structure as anchorage points for part or all of the pelvic restraint, provided care is taken to assure that the load path is as direct as possible, through the wheelchair structure into the mobility aid tiedown (see 4.4.5.3 below), to minimize bending loads on the wheelchair. SAE J2249 shall be used to guide design of such modified anchorage points.

Figure 4.5-1 illustrates proper location of occupant protection systems and anchor points.

4.4.5.2.2 Passenger Restraint Usability (Independent Driver)

All independent driver occupant protection systems installed or modified as part of an adaptive equipment modification to a motor vehicle shall be usable for independent operation by the intended driver. Every effort shall be made to make such systems as easy to use as the OEM system, taking into consideration the abilities of the intended user.

4.4.5.2.3 Airbags

Where motor vehicles are equipped with airbags for occupant protection, every effort shall be made by modifiers to retain the airbags in an operational mode. Certain modifications, circumstances, and equipment may make it necessary to remove or render inoperative an airbag, or remove or disconnect an airbag sensor in order to accommodate the driver's needs and achieve the goal of independent transportation. Under these conditions or if the modifier has written notification from the customer's physician that the airbag should be disconnected or removed, the TWC VRD PSART shall be advised of the necessity of disconnecting or removing the airbag

Figure 4.5-1

4.4.5.3 Wheeled Mobility Aid Tiedowns

The tiedown restrains the mobility aid during the transfer process and/or while the vehicle is it motion. The tiedown should be independently operable by the client and should be labeled "Unoccupied Mobility Aid Only", unless the tiedown has been safety tested and approved for occupied use. In view of the state-of-the-art in occupied mobility aid tiedowns and the inherent unsuitability of standard wheeled mobility aid designs for use as vehicle seating, nothing in this section should be construed as reflecting any TWC

VRD policy encouraging the use of mobility aids as vehicle seats. but rather recognizing that certain individuals can be transported in no other way. TWC VRD policy is to encourage any passenger or driver, when practicable, to transfer from a mobility aid to a properly designed vehicle seat. Scooters or other similar designs of wheeled mobility aids are less suitable for vehicle seating than are wheelchairs. The use of scooter type mobility aids as seating shall be evaluated by TWC VRD PSART on an individual case basis before such an adaptation can be accepted. The tiedown for any occupied wheeled mobility aid shall be so situated that the occupant is facing forward.

4.4.5.3.1 Wheeled Mobility Aid Tiedown Design Requirements

Occupied wheeled mobility aid tiedowns shall meet SAE J2249S as applicable, and shall:

- Be designed to provide mobility aid and occupant restraint protection under the dynamic conditions of a 30 MPH frontal collision into an immovable barrier, equivalent to an average declarative force of 20 G on the torso of the occupant. If the tiedown is unoccuppied and used as a mobility aid tiedown only the same declarative force of 20 G will be applied with the surrogate wheelchair attached to the tiedown. Evidence of acceleration test results to document attainment of this design requirement shall be submitted in writing to the TWC VRD PSART
- Interface with the main structure of the mobility aid, specifically excluding any wheels or parts of wheels, detachable components such as footrests, or seat rails
- Not depend upon brakes for stability or securement
- Be installed by means of attachment hardware that is connected to the structure of the motor vehicle in a manner comparable to vehicle seat installation
- When occupied the OEM seat belts shall not be used for mobility aid securement

4.4.5.3.2 Wheeled Mobility Aid Tiedown Innovative Designs

TWC VRD recognizes that innovative designs for wheeled mobility aid tiedowns may use approaches not envisioned under the guidelines of this Standard, and thus the criteria identified in 4.4.5.3.1 may not be applicable in part or as a whole. The burden of proof is upon the manufacturer or supplier of such a system to provide documentation to the TWC VRD PSART, based on engineering analysis and test results, that the intent of this Standard has been satisfied (See Section 4.1.1).

4.4.5.3.3 Wheeled Mobility Aid Tiedown (Occupied, Driver) Special Design Provisions

A wheeled mobility aid tiedown for a driver of a motor vehicle who must use a mobility aid as a vehicle seat shall meet all the requirements of 4.4.5.3.1 or 4.4.5.3.2, and shall be designed to be operable by the driver without assistance. The tiedown shall incorporate provision for the driver to verify that positive engagement of the tiedown has been effected. In the event of tiedown component or power source failure, provisions shall be made for the independent driver to effect emergency release.

4.4.6 Vehicle Structural Modifications

Vehicle bodies may require modifications to accommodate the special needs of drivers with disabilities. Where such modifications are required, every effort shall be made to preserve the structural integrity of the vehicle. The guidelines provided in SAE J1725, should be followed as closely as possible by modifiers. Vehicles that do not have a separate body and frame (usually termed "uni-body") are more difficult than those with separate body and frame to incorporate structural modifications that are structurally sound and durable for the life of the vehicle.

4.4.6.1 Flooring

Flooring is a covering over the surface of the structural floor of the vehicle which promotes ease of use and safety of a wheeled mobility aid. Factory installed (OEM) flooring is excluded from the provisions of this section of the Standard.

4.4.6.1.1 Flooring Design Requirement

On ribbed vehicle floors, sub flooring shall be constructed either of plywood (exterior grade or better) with a minimum thickness of 3/8 inch or of sheet steel at least 20 gauge. On flat vehicle floors, provided the structural requirements of 4.4.6.2, 4.4.6.3, or 4.4.6.4 are met, or the flat floor is OEM, no sub floor is required. Other materials may be acceptable as equivalent in structure to plywood or sheet steel, but their use must be reviewed by the TWC VRD PSART. Flooring must not perceptibly sag under a 600-lb load. Provisions shall be made to prevent excessive heating of the vehicle floor by engine or exhaust components.

The driver step well (if any) shall be covered over or otherwise protected unless otherwise specified. The flooring shall not have gaps between sections greater than 1/8 inch, nor have rough edges that could catch or impede a wheeled mobility aid.

Surface material suitable for use with the wheeled mobility aid shall be securely attached over the entire area of the flooring. The surface material shall be smooth, non-skid commercial grade flooring.

4.4.6.1.2 Sub- Flooring Installation

Installation shall be designed to be permanent. Method of fastening may be bolts, rivets, spot welding, bonding or other methods that satisfy 4.3.5.

4.4.6.2 Full-size Van Lowered Floor (Separate Body and Frame)

A lowered floor may replace part or the entire OEM floor, or be a boxlike section with a sloping side which merely allows a wheeled mobility aid to descend to a lower height within the van, or it may be a structure which supports or otherwise is integral with a lowering pan. OEM floors are excluded from the provisions of this standard.

4.4.6.2.1 Full-size Van Lowered Floor Design (Separate Body and Frame) Requirements.

The lowered floor shall be constructed of a minimum of 12 gauge steel.. Adequate clearance shall be maintained between the body structure and the frame (to allow for separate movement) in order to prevent mechanical noise, vibration, and shock. In order to obtain sufficient floor drop to accommodate the intended driver eye height, and maintain the aforesaid clearance it may be necessary to raise the vehicle body higher than the OEM body mounts. Where spacers or modifications to the body mounts are required, all mounts shall be retained and so modified. Body raises more than 2.5 inches require review on a case-by-case basis for acceptance.

4.4.6.2.2 Full-size Van Lowered Floor (Separate Body and Frame) Installation.

Every effort shall be made to avoid compromise to the vehicle structural integrity in cutting the van floor and installing the lowered floor. The vehicle chassis or frame shall not be cut or modified in any manner to accommodate a lowered floor without prior review by the TWC VRD PSART.

. All seams shall be waterproof and treated to prevent corrosion through application of a suitable sealant, primer, and paint. An undercoating shall also be applied to the exterior surfaces of the lowered floor. Provisions shall be made to insulate and protect the underside of the floor from hot components (e.g., catalytic converter, exhaust system, etc.). Installation shall not leave gaps or holes of any kind between the original floor and the lowered floor.

4.4.6.3 Full-size Van Lowered Floor (Uni-body)

Modification of either the basic structure and/or the suspension of a uni-body van to install a lowered floor is considered to constitute a remanufacture of the original vehicle. Accordingly, the TWC VRD PSART will only accept such remanufacture of a new vehicle, i.e., a vehicle which has never been registered, but exceptions to this policy may be granted on a case-by-case basis. Remanufacture can only be undertaken by an intermediate or second-stage manufacturer as defined in Title 49, Part 568 of the Code of Federal Regulations. The modifier shall provide evidence to the TWC VRD PSART that they are so registered with the U.S. Department of Transportation.

4.4.6.3.1 Full-size Van Lowered Floor (Uni-body) Requirements

Extent of Conversion—A uni-body van conversion which consists of a lowered floor structural remanufacture shall not also incorporate a raised roof or provision of an extra (other than OEM) side door. Since the lowered floor modification of a uni-body is considerably more complicated and critical than installation of a lowered floor in a vehicle with a body mounted on a separate chassis, the provisions of this section of the TWC VRD Standard supersede those of 4.4.6.2 Lowered Floor (Separate Body and Frame) where conflict occurs.

Structural modifications shall be made of the same material as the original uni-body structure, e.g., if the body is made of sheet steel, the lowered floor shall also be

manufactured of comparable sheet steel of a thickness sufficient to restore the original structural strength of the uni-body.

Brakes—If a van conversion involves any change or modification to the OEM brake system, the intermediate manufacturer shall demonstrate that the conversion does not compromise brake performance. A facility acceptable to the TWC VRD PSART shall conduct a brake test supervised by a registered professional engineer in which an unmodified vehicle otherwise identical to a converted vehicle is compared in braking performance with that converted vehicle. "Identical" means same wheelbase, actual gross vehicle weight, model and year, tires, and brake configuration. The comparison vehicle may be the same vehicle prior to modification. The brake test procedure shall be that described in 49CFR571.105 (FMVSS 105), Paragraph S7 through S7.3. A mean stopping distance increase from the unmodified vehicle to the modified vehicle of more than 10 per cent disqualifies the vehicle conversion from acceptance. The intermediate manufacturer shall submit written documentation to the TWC VRD PSART stating either that the OEM brake system is unchanged or stating and describing what changes or modifications have been made and that the results of the above comparative test are applicable for that particular modification.

Ground Clearance—Any uni-body van conversion shall be designed to maintain a ground clearance of 6 inches at all points under the body, with the following exceptions:

- Exhaust pipe and associated components may extend downward an additional 2 inches, i.e., a resulting ground clearance of 4 inches.
- Tire and Wheel Assemblies (no restriction).
- The envelopes at each axle described by sweeping a vertical plane which is transverse to the longitudinal axis of the vehicle, forward and after 20 inches from the centerline of each axle or spindle (ground clearance of 4 inches).

Tire Changing Capability—Jacking points or similar provisions for raising any of the four wheels to effect tire change shall be provided. If a jacking mechanism other than the OEM jack is necessitated, such mechanism shall be provided as part of the conversion. A sticker next to the OEM jacking instruction sticker and revision to the owner's manual that provides jacking instructions for the modified vehicle shall be furnished by the modifier.

Towing—Any uni-body van conversion shall be designed to permit towing the vehicle with the driving wheels raised.

Effective Payload—A uni-body van conversion shall be designed to permit the vehicle to accommodate a payload of 1000 lbs. without exceeding the OEM maximum GVWR, as provided on the vehicle manufacturers label (OEM or as modified by the Second Stage Manufacturer).

4.4.6.3.2 Full-size Van Lowered Floor (Uni-body) Performance Requirements

FMVSS Requirements—The manufacturer shall comply with all applicable FMVSS requirements. When an FMVSS is made inoperative it shall be in accordance with the "make inoperative exemption" provided in Title 49 CFR 595.7. At a minimum, the intermediate manufacturer shall demonstrate by tests or certification as indicated below that the remanufactured vehicle complies with the following FMVSS (49CFR571) if the conversion involves modification of any part of the vehicle which could affect the OEM certification of compliance:

- 105 Hydraulic Brake Systems: by test
- 106 Brake Hoses: by certification
- 126 Electronic Stability Control
- 201 Occupant Protection in Interior Impact: by certification
- 203 Impact Protection for the Driver from the Steering Control System: by certification
- 204 Steering Control Rearward Displacement: by test
- 207 Seating Systems: by test
- 208 Occupant Crash Protection: by test
- 209 Seat Belt Assemblies: by certification
- 210 Seat Belt Assembly Anchorage: by test
- 214 Side Impact Protection
- 301 Fuel System Integrity: by test

The above list is not necessarily all inclusive of testing that may be required of a manufacturer for FMVSS's affected during the vehicle modification process.

Certification shall be provided in writing to the TWC VRD PSART on each version of the uni-body van conversion. Testing shall be accomplished by a facility acceptable to the TWC VRD PSART and shall be supervised by a registered professional engineer, with test reports and findings provided to the TWC VRD PSART for each version of the uni-body van conversion.

Occupant Protection—If second-stage remanufacture of the uni-body van includes provisions for either occupied or unoccupied wheelchair restraints or tiedowns, TWC VRD Standards Sections 4.4.5.3 and 4.4.5.4 are applicable in their entirety.

4.4.6.3.3 Warranties, Manuals, and Instructions

Warranties—The manufacturer of the uni-body van conversion shall provide a written warranty to the TWC VRD customer which parallels the OEM warranty and provides as a minimum a basic limited warranty for both parts and labor for 12,000 miles or 12 months, whichever comes first, for modifications and alterations made by that manufacturer. In addition, the intermediate manufacturer shall provide as a minimum a limited warranty for metal fabrication for 70,000 miles or 7 years, whichever comes first. Documentation of such warranty policy must be submitted to the TWC VRD PSART before a uni-body van conversion can be accepted.

In order to assure that timely and convenient service under the warranties can be obtained by a the TWC VRD customer, an intermediate manufacturer must have a dealer or otherwise authorized representative in a customer's local area before a uni-body van conversion can be accepted. "Local area" is herein defined as within a radius of 200 miles of the TWC VRD customer's home. Exceptions to this requirement will be evaluated on a case-by-case basis by the TWC VRD PSART.

Manuals and Instructions—The intermediate manufacturer shall provide operating and maintenance manuals and instructions in conformance with Paragraphs 4.3.7.2 and 4.3.7.3 of the TWC VRD Standards.

4.4.6.4 Minivan Structural Conversions

A minivan is herein defined as a front-wheel-drive uni-body vehicle which has a wheel-base of less than 122 inches (310 cm). Conversions covered by the scope of this Standard may include a lowered floor, mechanisms for lowering the vehicle to facilitate ingress and egress, and a ramp. Modification of either the basic structure or the suspension of the vehicle to install a lowered floor or a lowering capability is considered to constitute a remanufacture of the original vehicle. Accordingly, the TWC VRD PSART will only accept such remanufacture of a new vehicle, i.e., a vehicle which has never been registered, but exceptions to this policy may be granted on a case-by-case basis. Remanufacture can only be undertaken by a second-stage or intermediate manufacturer as defined in Volume 49 Part 568, Code of Federal Regulations. The modifier shall provide evidence to the TWC VRD PSART that they are so registered with the U.S. Department of Transportation.

4.4.6.4.1 Minivan Conversion Design Requirements

Extent of Conversion—A Minivan conversion which consists of a lowered floor structural remanufacture shall not also incorporate a raised roof or provision of an extra (other than OEM) side door. Since the lowered floor modification of a uni-body is considerably more complicated and critical than installation of a lowered floor in a vehicle with a body mounted on a separate chassis, the provisions of this section of the TWC VRD Standard shall supersede those of 4.4.6.2 or 4.4.6.3 lowered Floor where conflict occurs.

Structural modifications shall be made of the same material as the original uni-body structure, e.g., if the body is made of sheet steel, the lowered floor shall also be manufactured of comparable sheet steel of a thickness sufficient to restore the original structural strength of the uni-body.

Brakes—If a minivan conversion involves any change or modification to the OEM brake system, the intermediate manufacturer shall demonstrate that the conversion does not compromise brake performance. A facility acceptable to the TWC VRD PSART shall conduct a brake test supervised by a registered professional engineer in which an unmodified vehicle otherwise identical to a converted vehicle is compared in braking performance with that converted vehicle. "Identical" means same wheel-base, actual

gross vehicle weight, model and year, tires, and brake configuration. The comparison vehicle may be the same vehicle prior to modification. The brake test procedure shall be that described in 49CFR571.105 (FMVSS 105), Paragraph S7 through S7.3. A mean stopping distance increase from the unmodified vehicle to the modified vehicle of more than 10 percent disqualifies the vehicle conversion from acceptance. The intermediate manufacturer shall submit written documentation with each vehicle conversion to the TWC VRD PSART stating either that the OEM brake system is unchanged, or stating and describing what changes or modifications have been made and that the results of the above comparative test are applicable for that particular modification.

Ground Clearance - Driving Mode—Any minivan conversion shall be designed to maintain a ground clearance of 6 inches at all points under the body, with the following exceptions:

- Exhaust pipe and associated components may extend downward an additional 2 inches, i.e., a resulting ground clearance of 4 inches.
- Tire and Wheel Assemblies (no restriction).
- The envelopes at each axle described by sweeping a vertical plane which is transverse to the longitudinal axis of the vehicle, forward and aft 20 inches from the centerline of each axle or spindle (ground clearance of 4 inches).

Ground Clearance-Parked or Kneeling Mode—When parked on level ground, including the condition in which the vehicle has been lowered, if such provision has been installed, no part of the vehicle, other than the tire and wheel assemblies, shall touch the ground if any tire becomes deflated.

Tire Changing Capability—Jacking points or similar provisions for raising any of the four wheels to effect tire change shall be provided. If a jacking mechanism other than the OEM jack is necessitated, such mechanism shall be provided as part of the conversion. It shall be possible to remove and replace wheels on the vehicle in any operation mode, i.e., vehicle in driving configuration, and in lowered configuration (if provided). Such provisions should not be dependent upon any power system of the vehicle. A sticker next to the OEM jacking instruction sticker and revision to the owner's manual that provides jacking instructions for the modified vehicle shall be furnished by the modifier.

Towing—Any minivan conversion shall be designed to permit towing the vehicle with the driving wheels raised, including the condition in which the vehicle has been lowered, if such provision has been installed

Effective Payload—A minivan conversion shall be designed to permit the vehicle to accommodate a payload of 1000 lbs. without exceeding the OEM maximum GVWR, as provided on the vehicle manufacturers label (OEM or as modified by the Second Stage Manufacturer).

4.4.6.4.2 Minivan Conversion Performance Requirements

FMVSS Requirements- The manufacturer shall comply with all applicable FMVSS requirements. When an FMVSS is made inoperative it shall be in accordance with the "make inoperative exemption" provided in Title 49 CFR 595.7. At a minimum, the intermediate manufacturer shall demonstrate by tests or certification as indicated below that the remanufactured vehicle complies with the following FMVSS (49CFR571) if the conversion involves modification of any part of the vehicle which could affect the OEM certification of compliance:

- 105 Hydraulic Brake Systems: by test
- 106 Brake Hoses: by certification
- 126 Electronic Stability Control
- 201 Occupant Protection in Interior Impact: by certification
- 203 Impact Protection for the Driver from the Steering Control System: by certification
- 204 Steering Control Rearward Displacement: by test
- 207 Seating Systems: by test
- 208 Occupant Crash Protection: by test
- 209 Seat Belt Assemblies: by certification
- 210 Seat Belt Assembly Anchorage: by test
- 214 Side Impact Protection
- 301 Fuel System Integrity: by test

The above list is not necessarily all inclusive of testing that may be required of a manufacturer for FMVSS's affected during the vehicle modification process.

Certification shall be provided in writing to the TWC VRD PSART on each version of the minivan conversion. Testing shall be accomplished by a facility acceptable to the TWC VRD PSART and shall be supervised by a registered professional engineer, with test reports and findings provided to the TWC VRD PSART for each version of the minivan conversion.

Occupant Protection—If second-stage remanufacture of the minivan conversion includes provisions for either occupied or unoccupied wheelchair restraint, TWC VRD Standards Sections 4.4.5.3 and 4.4.5.4 are applicable in their entirety.

Ramps—installed as part of a minivan conversion shall meet the requirements of Section 4.4.3.5.

Vehicle Doors—modified as part of a minivan conversion shall meet the requirements of Section 4.4.6.8.

4.4.6.4.3 Warranties, Manuals, and Instructions

Warranties—The intermediate manufacturer of the minivan conversion shall provide a written warranty to the TWC VRD customer which parallels the OEM warranty, and provides as a minimum basic limited warranty for both parts and labor for 12,000 miles or 12 months, whichever comes first, for modifications and alterations made by that

manufacturer. In addition, the intermediate manufacturer shall provide as a minimum a limited warranty for metal fabrication for 70,000 miles or 7 years, whichever comes first. Documentation of such warranty policy must be submitted to the TWC VRD PSART before a minivan conversion can be accepted.

In order to assure that timely and convenient service under the warranties can be obtained by a TWC VRD customer, an intermediate manufacturer must have a dealer or otherwise authorized representative in a customer's local area before a minivan conversion can be accepted. "Local area" is herein defined as within a radius of 200 miles of the TWC VRD customer's home. Exceptions to this requirement will be evaluated on a case-by-case basis by the TWC VRD PSART.

Manuals and Instructions—The intermediate manufacturer shall provide operating and maintenance manuals and instructions in conformance with Paragraphs 4.3.7.2 and 4.3.7.3 of the TWC VRD Standard.

4.4.6.5 Fuel Tanks

4.4.6.5.1 Fuel Tank Protection

With the installation of a lowered floor, it may be necessary to replace or relocate the vehicle fuel tank. Every consideration shall be given to providing the same degree of structural protection for the tank that was provided by the OEM. A part or surface of a relocated fuel tank should not protrude below the chassis of the vehicle such that it is the lowest portion of the underside of the vehicle on a longitudinal line from that point to the front of the vehicle. This might be the part of the vehicle that would first contact an obstacle on the pavement surface. Where such projection by a relocated fuel tank cannot be avoided, the tank shall be provided with a shield for the front and bottom. The shield shall be fabricated of 14 gauge or thicker steel, or equivalent material. The shield shall be designed to deflect oncoming objects away from the tank, and to protect the bottom of the tank itself. The shield shall be designed to be removable for service access to the fuel tank (including removal of the tank) without the use of a cutting torch or other methods of cutting metal.

4.4.6.5.2 Fuel Tank Replacement

Replacement tanks shall be certified by their manufacturer to meet FMVSS 301, and shall be installed in accordance with manufacturer recommendations. Every consideration shall be given to providing the same degree of structural protection for the tank that was afforded the OEM tank in its original position. A part or surface of a replacement fuel tank should not protrude below the chassis of the vehicle such that it is the lowest portion of the underside of the vehicle on a longitudinal line from that point to the front of the vehicle, and thus might be the part of the vehicle that would first contact an obstacle on the pavement surface. Where such projection by a relocated fuel tank cannot be avoided, the tank shall be provided with a shield for the front and bottom. The shield shall be fabricated of 14 gauge or thicker steel, or equivalent material. The shield shall be designed to deflect oncoming objects from the front of the vehicle downward and away

from the tank, and to protect the bottom of the tank itself. The shield shall be designed to be removable for service access to the fuel tank (including removal of the tank) without the use of a cutting torch or other methods of cutting metal which involve heat or flame. Where damage from underride or striking a high curb is likely, a suitable guard or bumper structure shall be provided (e.g., a trailer hitch assembly could provide adequate underride protection for an aft-of-axle fuel tank installation).

4.4.6.6 Lowering Pan

A lowering pan is a lowered floor in a van or van-type vehicle which incorporates an electrically, pneumatically, manually or hydraulically powered device to lower a person in a wheeled mobility aid and its occupant down into a well which places the occupant at an appropriate eye height from which to drive or ride as a passenger. OEM devices to accomplish this purpose are excluded from the provisions of this Standard.

4.4.6.6.1 Lowering Pan Design Requirements

The structure of the pan constitutes a lowered floor, and as such shall conform to 4.4.6.2. If the lowering pan also provides occupied wheeled mobility aid restraint, the lowering pan shall meet all of the requirements for occupied wheeled mobility aid restraints, as applicable, contained in 4.4.5.2. Controls for operating the lowering pan shall be placed so as to be accessible at all time by the user if he or she is an independent driver. Direction of movement of the lowering pan controls shall be consistent with the direction of translation of the user.

Any surfaces of the lowering pan which interface with the wheeled mobility aid wheels shall be covered or coated with a nonskid surface material.

The lowering pan mechanism shall have provision for positive locking in position at either extent of travel, unless the method of raising or lowering is by means of a self docking power actuator.

Any cable, wire bundle or other connective device associated with a lowering pan shall be designed to remain clear of pinch points, abrasion, or other damage and to remain connected throughout the range of movement of the pan. Individual wires or hoses shall be bundled or secured in a workmanlike manner.

4.4.6.7 Raised Roofs

Raised roofs are structural modifications to any motor vehicle that substitute an after-market roof for the original roof of the vehicle body. The after-market roof is installed to increase vertical clearance inside the vehicle to facilitate entry, exit, and maneuvers inside the vehicle by a person in a mobility aid. Such a structural conversion is very common in the recreational vehicle industry, and is usually applied to vans, either full-sized or minivans, and to other similar vehicles.

4.4.6.7.1 Raised Roofs Design Requirements

Raised roofs shall be constructed of durable materials suitably finished to resist the effects of sunlight, moisture, snow and ice, and temperature extremes. Any fixtures mounted in such a roof such as windows, ventilators, antennas, etc. shall be designed to be air and moisture leak resistant.

The principal objective of this Standard is to prevent any unreasonable compromise to vehicle structural integrity presented by removal of the original sheet metal roof and reinforcing members, and substitution of a raised roof. Thus any raised roof conversion which does not restore such rigidity and is not an integral structure with the body of the vehicle, shall be provided with suitable reinforcement members. This structure is not to serve as a roof support nor act as a roll bar but rather to provide rigidity to the tops of door and window posts, rigidity that was lost when the original vehicle roof was removed.

The minimum reinforcement structure for a raised roof that requires such a structure shall consist of two transverse members that follow the new roof- line connected by at least two equally spaced longitudinal members. This structure shall be attached to a header (longitudinal base member) which shall be installed along the top interior sides of the vehicle body. In some cases, sufficient structure may remain to permit the reinforcement structure to be welded or bolted to the body directly, without the use of such a header. The location of the forward transverse bar shall be just ahead of the side door on a van, or directly behind the front seat line; the location of the after transverse bar shall be just aft of the side door opening or rearmost side door. Both transverse bars shall be designed to be located directly over the side door pillars, or as close to those centers as is practicable, and designed to be tied into those structures. Nothing in this paragraph shall be construed to prohibit vehicle modifiers from supplying additional structure in excess of these minimum requirements.

All transverse and longitudinal members and headers shall be constructed of 1 inch minimum outside diameter steel tubing, of 16 gauge thickness or thicker, or of any other structural shape of equivalent strength. The entire reinforcing structure shall be welded using methods specified in AWS D1.3 "Structural Welding Code, Sheet Metal."

4.4.6.7.2 Raised Roof Installation

All sharp edges left by removal of the OEM roof shall be suitably protected or covered to prevent injury to vehicle occupants. All such body work shall be primed and painted in accordance with accepted standards of automotive practice, and shall be comparable to original finish. Installation of the raised roof shall be accomplished with sealant at the seams or a gasket so as to preclude air or water leaks.

Any reinforcement structure shall be rigidly attached to the original vehicle structure, especially to the vertical pillars in that structure. Method of attachment may be by

welding using methods specified in AWS D1.3 "Structural Welding Code, Sheet Steel," or may use attachment hardware with suitable automotive quality bolts that meet applicable SAE fastener. The reinforcement structure shall be covered with padding or other material to prevent chafe and wear at any point that this structure comes into contact with the raised roof. A raised roof shall not be used as a mounting surface or anchor for assist handles or other devices which place a significant load on the mounting surface, unless the roof is specifically designed or modified for such an installation. Under no circumstances shall a raised roof of any kind alone be used for passenger or driver restraint anchorage. A reinforcement structure may be used for such occupant restraint provided that it is not the only anchorage structure so used; and provided that the reinforcement structure is shaped, sized, and connected to resist the appropriate loads.

4.4.6.8 Modified Doors

Any alteration to the OEM vehicle doors that necessitates changes to the door- frame constitutes a modified door. These modifications may be accomplished to increase entry height or width to accommodate a raised roof or wheelchair lift installation, or for other special needs.

4.4.6.8.1 Modified Door Design Requirements

Extensions to doors to make them higher or wider shall be accomplished in such a manner as to preserve the original door strength and rigidity. Corresponding alterations to door pillars and frames shall also preserve the structural integrity of the original body member. Replacement glazing shall be comparable to OEM glass and shall meet the requirements for safety glazing material in motor vehicles as set forth in Texas Traffic Laws, TWC VRD Para 547.608. All such body work shall be primed and painted in accordance with accepted standards of automotive practice, and shall be comparable to original finish.

Trim of the interior of a modified door shall be comparable to the original trim of the door. Door modifications shall be free of exposed burrs or sharp metal edges. A modified door or doorframe shall incorporate gaskets and a drip rail to prevent intrusion of water.

All modified doors shall retain the OEM latch system, per FMVSS 206.

4.4.7 Vehicle Electrical Modification

4.4.7.1 Battery and Charging Systems

Any vehicle modification which adds electrically powered equipment not originally designed for that vehicle creates a load on the battery and charging system which may compromise vehicle reliability. The intent of the requirements in this section is to help

assure that independent drivers will be able to release themselves from restraint and tiedown equipment and exit the vehicle if the main battery fails.

4.4.7.1.1 General Battery and Charging Systems Design Requirements

Battery Status Indicator—Any vehicle modification which requires battery power for entry to or exit from the vehicle shall include a device to display battery and charging system status (not just charging system status alone). Both under voltage and over voltage conditions shall be indicated, and provision shall be made to alert to the driver that an abnormal condition exists. If a second battery is required, that battery shall also be provided with a device to indicate that battery status. Such battery status indicators shall include provisions for limiting current drawn from the battery or batteries in the event of a fault in the circuit. These indicators permit the driver to make an informed decision as to whether to continue the trip or exit the vehicle.

When Second Battery is Required—A second battery shall be provided if the independent driver relies upon electrically powered or controlled equipment (e.g., wheelchair lift and door openers)for exit and is unable otherwise to exit the vehicle. Two different approaches may be taken to meet this requirement: provision of an access battery or reserve battery.

4.4.7.1.2 Access Battery

4.4.7.1.2.1 Access Battery Design Requirements.

Function—An access battery powers the electrical equipment required for entry to and exit from the vehicle if the main vehicle battery fails. This shall include any electrically powered equipment that is used by the vehicle operator to enter and exit the driver location and the vehicle. (eg. Transfer seat, tiedowns, lift, hoist, ramp, side door, etc.) This system must be able to be activated and stay engaged for the independent driver to exit the vehicle. The independent driver should not have to hold buttons down or switches on to have the access battery system function. A visual or audible alarm shall be installed to inform the operator the access battery system is engaged.

Isolation—If an access battery is provided, and only one alternator supplies charging current to both batteries when the engine is running, the vehicle shall be equipped with a charging circuit or device that automatically prevents one battery from depleting the other, and charges both from the alternator. The two batteries shall remain electrically isolated from each other at least when the engine is not running. A provision for momentary connection of the batteries at any time for the purpose of "jump starting" may be installed. If a separate alternator is provided for each battery, no isolating circuit or devices are required.

Jump Start—If such a "jump start" provision is made, the control shall be either a momentary switch which must be held on to provide the connection, or provision must be made to warn the driver that the two batteries are no longer isolated. Capacity—An access battery shall be of adequate capacity to power the equipment connected to it for its

design life under the expected normal operating conditions of the vehicle. A battery shall be adequate in capacity to power at least four complete cycles of operation of all access equipment under the most extreme detrimental environmental conditions expected

4.4.7.1.2.2 Access Battery Installation

Location—The access battery should be installed outside the passenger compartment.

Automatic Charging- The access battery charging must be automatic. The access battery system should receive charge from the vehicle's OEM charging system with no action required by the operator.

Mounting--The access battery must be retained by a mounting method equivalent to or better than the OEM battery mount. Use of a plastic container/ battery box for mounting purposes is not accepted. However, a plastic container/battery box is acceptable as an enclosure.

Charge Indicator- A indicator must be supplied that will inform the operator of the charge status of the access battery. This may be a voltmeter, digital display, green light, etc. The indicator must show the operator when the access battery is below a full state of charge. The indicator must be installed to read/show the access battery voltage only.

Inside Passenger Compartment—If an access battery must be installed inside the passenger compartment, it shall be housed in a non-conductive enclosure designed for this purpose, and the battery shall be of permanently sealed design. The enclosure shall be designed to resist damage from leakage of electrolyte from the battery case. The enclosure shall be labeled with the words REPLACE BATTERY WITH EQUIVALENT CAPACITY PERMANENTLY SEALED BATTERY.

Service Accessibility—Any installation of a battery in other than an OEM carrier and location should be accessible for inspection and maintenance without removal of major vehicle components, the use of special tools, or necessity to raise the vehicle if the battery requires servicing or periodic inspection.

Circuit Breaker—For any access battery installation, the ungrounded power cable shall be protected from short circuit by an automatically resetting circuit interrupter at the access battery, (before the cable passes through a metal body or frame member) and within approximately 12 inches of the OEM battery.

4.4.7.2 Other Electrical Requirements

4.4.7.2.1 Provisions for Ground

Where adaptive equipment depends upon grounding of the structure to which it is attached to complete the circuit to the equipment, a ground strap of equal or larger gauge from the battery powering the equipment to that structure shall be provided.

4.4.7.2.2 Other Electrical Modifications

Other modifications or additions to the motor vehicle electrical system or devices powered by the motor vehicle electrical system not covered by 4.3.4, and 4.4.7.1 shall be subject to individual consideration and approval by the TWC VRD PSART.