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National Workshop on Bus-Wheelchair Accessibility

Guideline Specifications for Active Wheelchair Lifts

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Office of Technical Assistance
Office of Bus and Paratransit Systems

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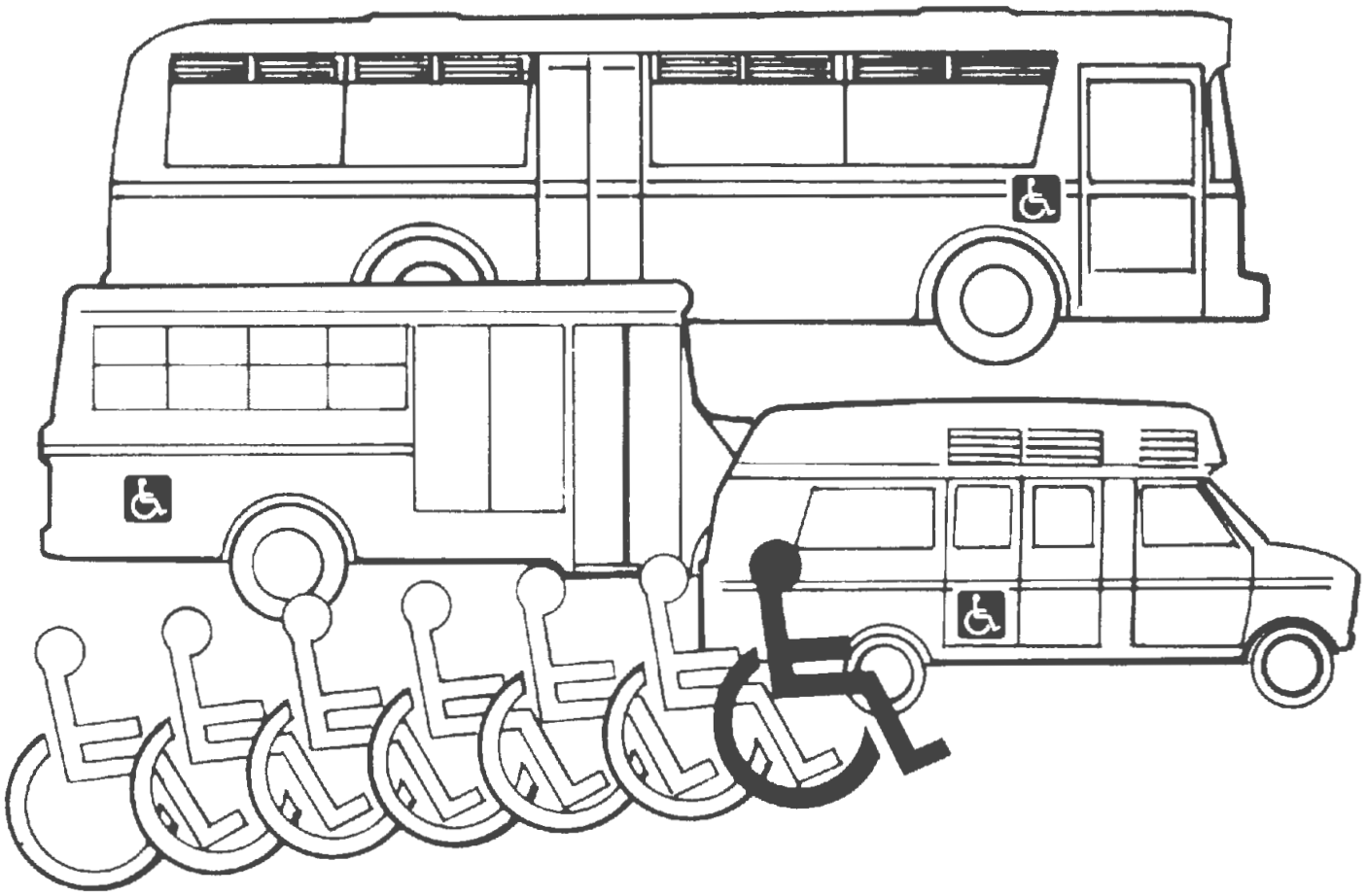

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Guideline Specifications for
Active Wheelchair Lifts

May 7-9, 1986
Seattle, Washington

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ACKNOWLEDGMENTS

These guideline specifications are the culmination of many hours of hard work by persons representing all facets of the accessible transit and paratransit industry. The Urban Mass Transportation Administration (UMTA) recognized that the technology associated with accessible transportation could be improved and sponsored an Advisory Panel in order to develop industry guideline specifications. Representing different viewpoints and different interests, the members of the Advisory Panel met, discussed issues, and developed these guideline specifications. It is a credit to the Advisory Panel and the dedication of its members that a formal vote never had to be taken and that the guideline specifications were developed on the basis of consensus.

Several people need to be acknowledged for the assistance they provided to the Advisory Panel in the development of these guidelines. George I. Izumi, the UMTA Project Manager, was responsible for planning and organizing the Advisory Panel, planning for the Workshop, and contributed greatly to the development of the guidelines. Vincent R. DeMarco, the UMTA Program Manager, was responsible for guiding the efforts of the Advisory Panel and for planning and conducting the Workshop. Two other persons from the U.S. Department of Transportation also provided assistance. Christina Chang of the Transportation Systems Center helped to organize and run the Workshop and prepare Workshop Proceedings. Scott York of the National Highway Traffic Safety Administration participated in the Advisory Panel meetings and assisted in clarifying certain safety issues. The Battelle project team of Gerald A. Francis (consultant), Martin Gombert (ATE Management and Service Company, Inc.), Rolland D. King, and David M. Norstrom was responsible for developing the draft guideline specifications and serving as a technical resource to the Advisory Panel. Special recognition is given to Mr. Norstrom who skillfully managed the guideline development process and led the discussions of the Advisory Panel meetings that obtained a general consensus of the Advisory Panel on each guideline subject. Finally, appreciation goes to each member of the Advisory Panel who gave of their time and contributed their expertise to the development of these industry guidelines.

PREFACE

On September 17, 1985, the Administrator, Ralph L. Stanley, of the Urban Mass Transportation Administration called together a meeting with representatives of transit agencies, handicapped organizations, rehabilitation specialists and manufacturers of buses and wheelchair lifts to hear first hand the problems and issues regarding transit bus wheelchair accessibility. As a result of this meeting, the Administrator requested that an UMTA Advisory Panel be formed to plan a National Bus Wheelchair Accessibility Workshop and to guide the development of a set of guideline specifications for the equipment required for transit bus and paratransit vehicle wheelchair accessibility. A contract was issued to Battelle to assist UMTA in this effort.

As a result of surveying the transit industry for input and meeting with the Advisory Panel, Battelle prepared a draft set of guideline specifications for wheelchair lifts, securement devices and ramps for presentation and discussion at the National Bus Wheelchair Accessibility Workshop held in Seattle, Washington, on May 7 through 9, 1986. Using the inputs developed during the Workshop and the written comments submitted following the Workshop, the Advisory Panel prepared these final guideline specifications.

These guideline specifications are advisory in nature. The intention of the guideline specifications is to provide transit agencies with a model that they could use, as appropriate, in the development of their specifications for wheelchair accessibility. In the guideline specifications, where the word "should" is used, the recommendation of the Advisory Panel is that the suggested item or value be included in a general specification. Where the word "may" is used, the Advisory Panel recommends that the item or choice of values be considered for inclusion based upon local operating conditions. The Advisory Panel has developed these guidelines for use throughout the United States. It recognizes that unique local conditions could make an item suggested for inclusion inappropriate and a local public transportation provider would be required to make the appropriate changes (e.g. to accommodate extreme environmental conditions).

This guideline specification is one of four specifications developed by the Advisory Panel, which developed separate guideline specifications for passive wheelchair lifts (those used primarily on transit buses), active wheelchair lifts (those used primarily on paratransit vehicles), ramps and securement devices. Members of the Advisory Panel participated actively in the development of each individual guideline specification based upon their experience and interest. Although the Advisory Panel discussed many related accessibility issues, these guideline specifications focus only on the technical requirements of a specific piece of equipment. They have been prepared to assist in the purchase of such equipment either separately or as part of an overall vehicle procurement.

ADVISORY PANEL

The following individuals participated in the Advisory Panel for the development of the draft guideline specifications of passive wheelchair lifts, active wheelchair lifts, ramps, and wheelchair securement devices.

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1.0 GENERAL

1.1 Scope

These guideline specifications relate to active lifts that are used by handicapped individuals to assist in boarding public transportation vehicles. An active lift is defined as a lift that when stowed may interfere with the use of the vehicle entrance in which the lift is located. As a result, active lifts usually have an entrance door separate from the regular passenger door. These guideline specifications have been developed with special concern for the safety of passengers using a lift and reliability of lift operations.

1.2 Definitions

The following definitions apply for this document.

Accessible Vehicle - A vehicle that has been equipped to allow boarding by passengers who by reason of handicap are physically unable to board a vehicle that has not been so equipped.

Active Lift - An active lift is one that when stowed may interfere with the use of the vehicle entrance where the lift is located and that when being raised or lowered operates primarily outside the body of the vehicle.

Arc Lift - This term denotes the type of lift that has an arcing motion during operation as differentiated from elevator lift.

Automatic Lift - This term refers to an active lift that has powered up, down, fold, and unfold functions.

dBA - This term denotes decibels with reference to 0.0002 microbar as measured on the "A" scale.

Design Load - The maximum weight capacity a lift is designed to raise or lower.

Drifting - The unintended movement of a lift from a stowed position.

Elevator Lift - This term denotes the type of lift that has a vertical up and down movement as differentiated from an arc lift.

Factor of Safety (Design Safety Factor) - The factor of safety is the ultimate strength of a material divided by the working stress. A structure fails or breaks when loaded to its ultimate strength. A structure deforms or takes set when loaded to its yield strength.

Fail-safe - A characteristic of a system and its elements whereby any malfunctions affecting safety will cause the system to revert to a known safe state.

Fold - The term designating the operation of lift from an operating position to a stowed position on the vehicle.

Interlock - The arrangement in which the operation or position of one mechanism automatically allows or prevents the operation of another.

Lift or Wheelchair Lift - A level change device used to assist those with limited mobility in the use of transit and paratransit services. The term lift and wheelchair lift are used interchangeably in this document.

Maintenance Personnel Skill Levels - Maintenance personnel skills used in this document are defined in accordance with the White Book specifications as follows:

5M: Specialist Mechanic or Class A Mechanic Leader
4M: Journeyman or Class A Mechanic
3M: Service Mechanic or Class B Serviceman
2M: Mechanic Helper or Coach Serviceman
1M: Cleaner, Fueler, Oiler, Hostler, or Shifter.

May - This term is to be construed as permissive.

Mechanical and Hydraulic Components - Mechanical and hydraulic components include all parts of the lift drive or control system that are subject to wear and degradation due to the operation of the lift.

Paratransit Operation - Paratransit operation refers to a public transportation operation (service, vehicles, facilities, etc.) that is not a transit operation.

Passive Lift - A passive lift is one that when stowed allows the unimpeded use of the vehicle door in which the lift is located.

Pinching Point - A location where two closely spaced parts of machinery can move together to create a human hazard.

Semi-Automatic Lift - This term refers to an active lift that has powered up and down functions and requires manual operation for folding and unfolding the lift.

Shear Area - A hazardous condition or location where a moving part approaches or crosses a fixed part.

Should - The term is to be construed as recommended by the Advisory Panel.

Slip Resistant - A characteristic of a surface of a material that reduces unintended relative motion with respect to another surface with which it has contact.

Structural Elements - The structural elements of the wheelchair lift include those that support working loads and attach the lift to the

vehicle. They do not include mechanical and hydraulic components associated with operation and control of the lift.

Transit Operation - Transit operation refers to a public transportation operation (service, vehicles, facilities, etc.) that operates with fixed routes and fixed schedules.

Unfold - The term designating the operation of a lift from a stowed position on the vehicle to an operating position.

White Book -This term is the common name for "Baseline Advance Design Transit Coach Specifications," originally published by UMTA on April 4, 1977. It is now available from the American Public Transit Association.

Wheelchair - A seating arrangement that is positioned on wheels, may be powered or unpowered, and can be used to assist mobility limited individuals.

Wheelchair Securement Device - A device anchored to a vehicle and used to limit the movement of a wheelchair when the vehicle is in motion.

1.3 Abbreviations

The following abbreviations may be found in the guidelines.

ANSI --- American National Standards Institute

ASME --- American Society of Mechanical Engineers

ASTM --- American Society for Testing and Materials

CSA --- Canadian Standards Association

FMEA --- Failure Modes and Effect Analysis

FMVSS --- Federal Motor Vehicle Safety Standard

NHTSA --- National Highway Traffic Safety Administration

SAE --- Society of Automotive Engineers

SCRTD --- Southern California Rapid Transit District

UFAS --- Uniform Federal Accessibility Standards

UMTA --- Urban Mass Transportation Administration

VA --- Veterans Administration

1.4 Reference Documents

(1) American National Standards Institute
1430 Broadway, New York, N.Y. 10018

ANSI A17-1983
Elevator and Escalator Committee Interpretations
ANSI/ASME A17.1-1984
Safety Code for Elevators and Escalators
ANSI A90.1-1976
Safety Standards for Manlifts

(2) American Public Transit Association. "Baseline Advanced Design Transit Coach Specifications," includes Addendums 1 through 20 that were made to the April 1977 issue of the "Baseline Advanced Design Transit Coach Specifications," published by Urban Mass Transportation Administration. (Commonly known as The White Book.) American Public Transit Association. April 1983.

(3) Baumeister, Theodore, Avallone, Eugene A., and Baumeister, Theodore (III). Mark's Standard Handbook for Mechanical Engineers, Eighth Edition. New York: McGraw-Hill Book Company. 1978.

(4) California Administrative Code, Title 13, Chapter 2, Subchapter 4, Article 15. Wheelchair Lifts.

(5) Canadian Standards Association. "Motor Vehicles for the Transportation of Physically Disabled Persons," CAN3-D409-M84. Ontario, Canada: Rexdale. April 1984.

(6) Canyon Research Group, Inc. "A Requirements Analysis Document for Transit Vehicle Wheelchair Lift Devices." Prepared for Urban Mass Transportation Administration, Westlake Village, California. June 1978.

(7) "Federal Motor Vehicle Safety Standard," Code of Federal Regulations, Title 49, Part 571 No. 207, Seating Systems, and No. 210, Seat Belt Assembly Anchorages.

(8) Henderson, William H., Dabney, Raymond L., and Thomas, David D. Passenger Assistance Techniques: A Training Manual For Vehicle Operators of Systems Transporting the Elderly and Handicapped, Third Edition. Fort Worth, Texas: Transportation Management Associates. 1984.

(9) James, D. I. "A Broader Look At Pedestrian Friction." Rubber Chemistry and Technology, Volume 53, Pages 512-541.

(10) Panero, Julius and Zelnik, Martin. Human Dimensions and Interior Space. New York: Whitney Library of Design. 1979.

(11) Society of Automotive Engineers. Standards, Recommended Practices, Information Reports.

(12) Stewart, Carl F. and Reinl, Herbert G. "Safety Guidelines for Wheelchair Lifts on Public Transit Vehicles." Prepared for Urban Mass Transportation Administration (UMTA-CA-06-0098-80-1). California Department of Transportation. July 1, 1980.

(13) "Uniform Federal Accessibility Standards." Federal Register (49 FR 31528). August 7, 1984.

(14) "Veterans Administration Wheelchair Lift Systems: VA Standard Design and Test Criteria for Safety and Quality of Automatic Wheelchair Lift System for Passenger Motor Vehicles." Federal Register (43 FR 21390). May 17, 1978.

2.0 TECHNICAL REQUIREMENTS

2.1 General Requirements

The wheelchair lift should meet the technical requirements given in Section 2.0.

2.1.1 Operating Environment

The lift should operate in the temperature range of -10 F to 115 F, at relative humidities between 5 percent and 100 percent, and at altitudes up to 5,000 feet above sea level. Degradation of performance due to atmospheric conditions should be minimized at temperatures below -10 F, above 115 F, or at altitudes above 5,000 feet.

Special procedures, hydraulic fluids, and/or lubricants may be used to operate the lift for the low and/or high temperature operating conditions.

Rationale: The urban areas of the United States have broad ranges of climatic conditions. Weather data indicate that many cities have recorded 100 days or more per year of over 90 F temperatures. Likewise, many have recorded 20 or more days per year below 0 F. The annual rainfall ranges as high as 60 inches per year to a low of 4 inches per year. The normal snow and sleet precipitation in some cities reach 88 inches per year. The recommended guidelines cover a broad range of conditions found in the United States and are adapted from the White Book specifications.

2.1.2 Weight

The weight of the lift should not adversely affect the legal axle loadings, the maneuverability, structural integrity, or the safe operation of the vehicle in which it is installed.

Rationale: For legal and safety reasons the weight of the lift should not adversely affect the vehicle. Since existing lifts reportedly meet these requirements, the weights of existing lifts are considered acceptable. The recommended upper limits are 1,000 pounds for lifts installed on standard transit vehicles and 400 pounds on small vans and other vehicles.

2.1.3 Operation Constraints

2.1.3.1 The lift should operate when the bus is on level ground and up to road grades up to seven (7) percent or four (4) degrees.

2.1.3.2 The lift should operate when the bus is on level ground and when the bus is at an angle of plus or minus 8.7 percent or five (5) degrees due to road crowns, depressions, or curb geographics.

Rationale: A lift will operate in a variety of different topographical conditions and must do so safely and reliably. A balance needs to be made between the topographical conditions to be accommodated by lift design and the conditions where a lift will not be required to operate.

A seven percent grade specification is currently used by Seattle Metro in its lift procurement. Since Seattle has a relatively hilly topography, using its limit for road grade seemed reasonable.

No specification reviewed during the development of these guidelines identified any requirements in terms of the roll of the bus. However, the VA sets a limit of 9 degrees in any direction for the operation of a powered wheelchair. Since a lift can tilt up to 3 degrees (Section 2.2.5), the 5 degree parameter was chosen in order to be below the 9 degree figure when the 3 degree tilt is considered.

2.1.4 Boarding Direction

A lift should be capable of handling a wheelchair in both an outward and inward facing position on the lift.

Rationale: To accommodate the passenger and for emergency or other special conditions, the lift needs to be able to accept and operate with a wheelchair facing either inward or outward. Discussion by the Advisory Panel considered outward facing to be preferred, but both directions need

to be accommodated. Local operating policies may designate outward facing.

2.1.5 Location of Lift

The lift should be installed on the side of the vehicle opposite the driver's seat (recommended) or at the rear of the vehicle.

Rationale: An active lift usually requires a separate entry. For safety reasons the preferred location is the curb side of a vehicle. However, in some cases a rear entrance may be preferred (e.g., in order to better utilize interior space). A rear entrance was not recommended, by the Advisory Panel although they recognized that special situations exist. If a rear door lift is used, vehicle loadings and unloadings should occur at off-street locations.

2.1.6 Padding and Protective Covering

2.1.6.1 Pinching movements, shear areas, or places where clothing or other objects could be caught or damaged should be covered or in other ways protected to prevent passenger injury when lift is in operation.

2.1.6.2 All exposed edges or other hazardous protrusions on the wheelchair lift or on the bus in an area associated with the wheelchair lift or securement device (except the platform) should be padded with energy absorbing material to minimize injury in normal use and in case of accident.

Rationale: To ensure safer operations all potentially hazardous areas should be protected. This is especially true of lift operations where individuals with certain handicaps have limited control and/or feelings in parts of their body and may not sense a hazardous condition. When a hazardous area cannot be adequately protected, the lift manufacturer must use other means to ensure safety. One recommended alternative is a pressure sensing device that would automatically stop lift movement if an object were detected.

Tests have shown that edges and protrusions can be especially hazardous in accident situations. To reduce the potential danger, energy absorbing material should be used to protect these areas. The stowed platform should be protected on its edges. The Advisory Panel discussed having protection for the platform surface. When stowed the platform surface becomes a secondary "wall" inside the vehicle. A removable pad would provide additional protection, but was considered optional. California requires the pad but some states prohibit the pad because it reduces the field of vision.

2.1.7 Operation Counter (Optional)

The lift should have an operations or use counter that records each complete up and down cycle of the lift.

Rationale: A counter would provide data on lift use. The data would be especially useful in recording lift cycling, scheduling maintenance, and evaluating the performance of the lifts. The Advisory Panel considered this feature useful, but not required. Although a counter adds cost to the purchase price, the expense is considered to be offset by better maintenance and lower operating costs resulting from the use of the counter.

2.1.8 Power Source Interface

2.1.8.1 The lift should operate and meet all requirements of these guideline specifications while using the power sources on the transit vehicle.

2.1.8.2 For small transit and paratransit vehicles, wheelchair lifts may be powered by a heavy-duty alternator system or a dual battery system with batteries similar to that supplied by the manufacturer of the vehicle.

2.1.8.3 The lift should meet the requirements of these guideline specifications whenever the power sources are performing within their specified ranges. The lift should remain in a safe state during and following power source transients, including failure, that may be experienced on transit vehicles.

Rationale: The electrical interface between the vehicle and the lift is an important consideration in performance. This guideline is intended to ensure both proper interface consideration for normal operations and safe conditions in abnormal situations, including power source excursions and power failure. A heavy duty alternator or separate battery is recommended for small vehicles to provide for more reliable operations. While the requirement for safe lift operations during and following power source transients may be somewhat redundant with other sections of the guidelines, it serves to emphasize the importance of continued safe lift operations even during and following such power excursions.

2.1.9 Wheelchairs To Be Accommodated (Optional)

The contractor should identify the length, width, and height of the wheelchairs that can be accommodated by the lift.

Rationale: Platform size will limit the dimensions of wheelchairs that can use the lift. The contractor should indicate the characteristics of wheelchairs that can use the lift in order for the lift purchaser to understand clearly the limitations of the lift.

2.2 Platform

2.2.1 Dimensions

2.2.1.1 The lift platform should have a minimum clear width of 30 inches. It is desired to have a minimum clear width of 32 inches.

2.2.1.2 The minimum clear length of the lift platform as measured between the outer barrier and the inner edge or roll stop should be 40 inches. At a length two and one half inches above the platform, the clear length should be 44 inches. It is desired to have a clear length of 44 inches at platform level and 48 inches, two and one half inches above the surface.

2.2.1.3 The minimum height of the door opening at the wheelchair lift should be 56 inches.

Rationale: The VA lift specification is a 29 inch width; and it identified current platform widths of 26 to 40 inches with an average width of 32 inches. The VA length specification is 44 inches. The Canadian Standard Association specifies dimensions of 30 and 38 inches. However, these are just platform dimensions and do not correspond to the size of wheelchairs that can be accommodated.

Estimates of current wheelchair sizes were obtained from two manufacturers and more detailed information was found in a 1978 report, "A Requirements Analysis Document for Transit Vehicle Wheelchair Devices." The data are summarized in the following table:

Estimate of Wheelchair Dimensions

	Invacare		1986 Everest & Jennings		1977 Everest & Jennings[1]	
Percentile	Length	Width	Length	Width	Length	Width
100/99	48	30	77-1/2[2]	28-1/2	47	31-7/8
95			52/47-1/2[3]	26-1/2	43-1/2	26-1/4
90	44	26		26-1/2	42-1/2	26-1/4
85					42	26-1/4
80	44	24				

(1) "A Requirements Analysis Document for Transit Vehicle Wheelchair Lift Devices," Canyon Research Group, Inc., June 1978.
(2) 77-1/2 inches represents a partially reclined, recliner wheelchair.
(3) 52 inches represents a recliner wheelchair and 47-1/2 inches represents a regular wheelchair.

The dimensions of the lift are influenced by vehicle characteristics. For example, on small vans the ceiling height can limit platform length. Also, standard door openings on small vehicles can limit platform widths. Increased door openings are a possibility, but this could reduce the number of seats in a vehicle and increase vehicle cost.

The dimensions of wheelchairs, existing specifications, and potential vehicle limitations were all considered in the development of the platform size specifications. The minimum size requirements will accommodate 90 to 95 percent of the wheelchair population; and the desired sizes will accommodate 99 percent of the wheelchair population.

The area of most concern is the length requirement. Door height on many current vans limit the lengths of platforms, and buses with greater door height are more expensive. The guideline has specified a minimum clear length of 40 inches. This means that at a minimum the lift will accommodate wheelchairs of this length. Also, recognizing the characteristics of wheelchairs, roll stops, and barriers, a minimum clear distance of 44 inches at a two and one-half inch height is specified. This approach allows wheelchairs with footrests that would overhang the platform and have a length equal to or less than 44 inches to use the lift. The dimensions in these guideline specifications represent a realistic balance between the design limitations of current vehicles and the wheelchair population. One class of wheelchairs that may be a problem are the newer three-wheeled models, which are longer than most other wheelchairs. The desired length requirements would accommodate a larger population of wheelchairs but could exclude the consideration of certain vehicles.

The height requirements are based on anthropometric data. Human Dimension and Interior Space cited 1963 data showing that 97.5 percent of males in wheelchair had a seated height of 51.5 inches or lower. No more recent data were cited. However, Human Dimension and Interior Space cited 1979 data on the seating height normal--the vertical distance from the sitting surface to the top of the head for a person in a relaxed position. The 95th percentile male has a sitting height normal of 36.6 inches. Adding 19 inches for the seat height of wheelchair results in an overall height of 55.6 inches. The 56 inch height requirement accommodates this height and is compatible with most vehicles. Interior vehicle height should be greater to accommodate movement inside the vehicle.

2.2.2 Surface

The platform surface should be slip resistant under the conditions defined in Section 2.1.1.

Rationale: A slip resistant surface reduces the potential for accidents and provides traction for a wheelchair.

2.2.3 Protrusions and Openings

2.2.3.1 When a barrier is down, the platform should have no protrusions from the surface greater than 1/4 inch or smooth rise greater than 1/2 inch, except for the stationary edge guards, inner roll stops, or outer barriers.

2.2.3.2 The lift platform should not have any openings greater than 3/4 inch in width, except for a hand hold not exceeding 1-1/2 inch by 4-1/2 inches located midway between the edge barriers on semi-automatic lifts.

Rationale: When lift barriers are down, movement on and off the platform should be easy and not inhibited by protrusions. A 1/4 inch protrusion can easily be negotiated by wheelchairs and is currently specified in the California Administrative Code.

It must be noted that the language, "when the lift barrier is down," has been chosen to allow protrusions when the barrier is up. Lift manufacturers have indicated that mechanisms to hold a barrier in place may require protrusions through the lift platform when the barrier is up. These protrusions are allowable, but should not limit the size or type of wheelchairs that can use a lift.

As discussed in Section 2.2.10, a lift platform may not be solid. The VA specifications use the 3/4 inch limit on openings; and it has been adopted for these guideline specifications. The exception to this requirement allows a hand hold for semi-automatic lifts.

2.2.4 Gap Dimensions

When a lift is at the floor loading and unloading position, the gap between the vehicle floor and the lift platform should be at a minimum. In no case should a gap have a vertical distance exceeding 5/8 inch or a horizontal distance exceeding 1/2 inch.

Rationale: A series of subjective tests reported in the VA specifications established the 5/8 inch vertical gap as the highest that should be allowed. The 1/2 inch horizontal gap was chosen to limit the overall gap opening to approximately 3/4 inch. The preferred option is to have no gap.

2.2.5 Platform Deflection

The lift platform should not deflect more than 3 degrees in any direction when tested in accordance with Section 3.1.3.

Rationale: To reduce the ability of a wheelchair to gain additional speed and overcome the barrier or roll stop and to reduce the chance of a wheelchair tilting off the lift, a maximum deflection standard is

established. The three (3) degree deflection is currently found in the California Administrative Code.

2.2.6 Edge Guards, Barriers, and Roll Stops

Use one of the following options. Option A should be used unless your operating procedures are in agreement with those described at the beginning of Option B.

Option A

2.2.6.1 Edge guards should extend the full length of the lift platform on both sides and shall have a minimum height of one and one-half (1-1/2) inch.

2.2.6.2 The lift should have an outer barrier or inherent design feature that retains a wheelchair on the platform when the platform is above the ground loading position.

2.2.6.3 The outer barrier or inherent design feature should be designed to meet the test requirements of Section 3.1.6.1.

2.2.6.4 The platform should have an inner roll stop or the design of the lift should use part of the vehicle as an inner roll stop. The inner roll stop or lift design should restrict the rolling movement of a wheelchair when the platform is in any operating position other than at the vehicle floor level position.

2.2.6.5 The inner roll stop should be designed to meet the test requirements of Section 3.1.6.3.

2.2.6.6 The contractor should identify and clearly emphasize in the operations and maintenance manuals any roll stop and barrier adjustments or maintenance actions that, if done improperly, could result in an unsafe condition.

Option B

When followed, operating procedures can reduce or eliminate potentially unsafe conditions. Recognizing that certain operating procedures can reduce certain risks and, therefore, change the safety requirements of a lift, this Option B is presented. Option B can be used when all of the operating procedures described in the following are adopted and mandated for use by a transit operator.

Operating Procedures

The objective of the following operating procedures is to eliminate the ability of a powered wheelchair to overcome a barrier and to provide safe lift operation. To accomplish this objective, the procedures are designed to disengage the power of a powered wheelchair and to require manual maneuvering of the wheelchair through the entire loading and unloading process, except when the lift is at the fully lowered position. The operating procedures are:

(A) With the lift platform in the lowered position, the wheelchair may be loaded by the passenger in the power mode or by the operator in a powered or unpowered mode. The wheelchair shall be loaded facing away from the vehicle with the operator on the ground either in front or to the side of the chair and platform.

(B) Before the lift is raised the operator shall:

(1) Ensure the power switch on the wheelchair is in the off position.
(2) Disengage all clutches on the wheelchair.
(3) Lock all wheelchair brakes, if possible.
(4) Ensure the passenger's hands and arms are resting in the passenger's lap or on the wheelchair arm rest away from the power control.

(C) The wheelchair shall be placed a sufficient distance in back of the barrier to allow unrestricted movement of the barrier to its locked position.

(D) The operator/driver shall physically check the barrier to make sure it is in a locked position:

(1) After the lift platform has been raised a sufficient distance above the ground for its locking mechanism to engage.
(2) Prior to loading a wheelchair on a lift platform when the lift platform is the raised position.

(E) During the raising or lowering of the lift platform, the operator/driver shall hold the wheelchair by an arm rest with his arm straight and elbow locked. The lift controls shall be operated with the other hand. The driver shall be standing on the ground with his feet apart when operating the lift.

(F) The operator/driver shall manually maneuver the wheelchair when it is onboard the vehicle.

(G) When loading the lift platform from the vehicle, the same operating procedures will be used. The wheelchair shall be placed a sufficient distance in back of the barrier to allow

unrestricted movement of the barrier, the operator/driver shall physically check the barrier to make sure that it is in a locked position, and during the raising or lowering of the platform the operator/driver shall stand beside the platform with his feet apart and hold the wheelchair by an arm rest with his arm straight and the elbow locked.

(H) The operator/driver shall be familiar with the instructions provided by the manufacturer on the safe loading of powered wheelchairs.

2.2.6.1 Edge guards should extend the full length of the lift platform on both sides and shall have a minimum height of one and one-half (1-1/2) inch.

2.2.6.2 The lift should have an outer roll stop or inherent design feature that restricts the rolling movement of a wheelchair on the platform when the platform is above the ground loading position.

2.2.6.3 The outer roll stop should be designed to meet the test requirements of Section 3.1.6.2.

2.2.6.4 The platform should have an inner roll stop, or the design of the lift should use part of the vehicle as an inner roll stop. The inner roll stop or lift design should restrict the rolling movement of a wheelchair when the platform is in any operating position other than at the vehicle floor loading position.

2.2.6.5 The inner roll stop shall be designed to meet the test requirements of Section 3.1.6.3.

2.2.6.6 The contractor shall identify and clearly emphasize in the operations and maintenance manuals any roll stop adjustments or maintenance actions that if done improperly could result in an unsafe condition.

Rationale: Edge guards can prevent a wheelchair from accidentally sliding over the sides of the lift. Since side barriers are not in the direct path of a wheelchair using a lift, they do not need to be designed to retain a wheelchair in direct forward or reverse motion.

In 1985, Garrett Engineers, Inc. conducted tests for the Southern California Rapid Transit District (SCRTD). These tests showed that barriers on all existing passive wheelchair lifts could be overcome by common powered wheelchairs. The powered wheelchairs could ride over the barriers or push them down. SCRTD initiated these tests following an accident investigation that indicated a powered wheelchair had defeated a barrier. Although active lifts were not tested, their design does not indicate they could retain a powered wheelchair on the lift.

Under Option A, the specifications require that the lift have a barrier that meets Section 3.1.6.1, which requires the barrier to prevent a powered wheelchair from leaving the platform. This requirement is aimed at eliminating the unsafe condition of a wheelchair powering over or through a barrier.

Under Option B, operating procedures are presented that eliminate the unsafe condition that requires a barrier that meets the test requirements of Section 3.1.6.1. In other words, the power and drive mechanism on a powered wheelchair are disabled. Under this option the test requirements for a roll stop (rather than barrier) are used. The test described in Section 3.1.6.2 is similar to that required by the VA. The VA tests were designed to retain a wheelchair without power on a lift platform.

The ability of a lift to stop rolling movement on the inner portion of the platform is required by Section 2.2.6.4. The requirement can be met by a roll stop or by a lift design that uses part of the vehicle as the roll stop.

The Advisory Panel considered the accident scenarios involving the inner roll stop different from that with the outer barrier. For this reason different tests are recommended. An inner roll stop will not necessarily prevent an activated powered wheelchair from leaving the platform, but must meet the requirements of Section 3.1.6.3.

Section 2.2.6.6 under both options requires the contractor to identify any roll stop and barrier adjustments or maintenance actions that if done improperly could result in an unsafe condition. This requirement is added to enhance overall safe operation of the lift.

2.2.7 Handrails

2.2.7.1 When the lift is fully deployed, the platform should be equipped with one handrail.

2.2.7.2 The top of the handrail should be 25 to 34 inches above the platform, should move with the platform, and should be at a minimum 24 inches in length.

2.2.7.3 The handrail should be capable of withstanding a horizontal force of 100 pounds concentrated at any point.

2.2.7.4 The handrails should be between 1-1/4 inches and 1-1/2 inches in diameter or width and should permit a full hand grip with no less than 1 inch of knuckle clearance.

Rationale: Current active lifts primarily operate with one or no handrail. Although for unassisted passengers handrails on both sides are preferable, handrails can be a hinderance when assistance is being provided. Two handrails reduce clear space above a lift platform and can

impair a driver from providing assistance both on and off the lift. Thus, handrails are recommended only for one side of the lift.

The handrail will provide support for passengers or a driver standing on the platform as well as for a person in a wheelchair. It should be noted that the Advisory Panel had differing opinions concerning persons not in a wheelchair being allowed on the lift. Some opposed standing on the lift, while others considered it an option.

Handrails that move with a lift provide more of a sense of security from a user's point of view than stationary handrails attached to the vehicle. Stationary handrails in effect move relative to the motion of the lift and are not as easy to grasp. Movable handrails are recommended by the Advisory Panel.

The vertical height dimensions and the 100-pound force requirement are adapted from the Canadian Standards Association standard. The handrail dimensions are the same as found in the White Book and in the Uniform Federal Accessibility Standards. Knuckle clearance in the UFAS is 1-1/2 inches. In the White Book it is 1 inch for door panels and 1-1/2 inches elsewhere. Although the 1-inch clearance has been chosen to coincide with door panel clearance of the White Book, such clearances must also meet the safety requirements of Section 2.1.6.1 concerning pinching movements and shear areas.

2.2.8 Platform Lighting

When the lift is in operation, the platform should have a minimum of one (1) foot-candle of illumination when deployed.

Rationale: Platform lighting provides for safer boardings when natural or other light is insufficient. The recommended level of illumination is adapted from the White Book specification. Nothing in this specification directs how the lighting is to be provided. The contractor has the option to make the lighting system part of the vehicle or part of the lift system.

2.2.9 Platform Markings (Optional)

2.2.9.1 The side edges, the outer edge, and the inner edge of the platform, or the inner edge of the floor of the bus adjacent to the lift should be clearly marked in a color different from the lift platform.

Rationale: This section is suggested. Members of the Advisory Panel differed on whether passengers should stand on a lift. However, it was agreed that these guidelines should not encourage the practice. Many transit operators provide wheelchairs for ambulatory passengers to use during boarding. The marking of the platform edges provides greater visibility and reduces the potential for accidents.

2.2.10 Line of Sight

When the platform is in a stowed position, it should not interfere with direct line of sight, especially between a passenger desiring to use the lift and the lift operator.

Rationale: The operational requirements of a lift may result in a lift operator and passenger being separated by the lift platform. The line of sight requirement means that in such a situation the platform should not impair sight contact. The operator should be able to see through or around the lift platform.

2.3 Structural

The structural elements of the wheelchair lift include those that support working loads and attach the lift to the bus. They do not include mechanical and hydraulic components associated with operation and control of the lift.

2.3.1 Lift Capacity

The wheelchair lift should have a lift capacity of 600 pounds uniform load.

Rationale: Discussion with wheelchair manufacturers indicated that the heavier, powered wheelchairs can weigh up to 250 pounds. The 99th percentile male weighs approximately 241 pounds. A combined weight is 491 pounds. Two 99th percentile males (one handicapped person and one attendant) combined with a heavy manual wheelchair would have a weight of approximately 540 pounds. The current wheelchair market would appear to be accommodated by a design load of 600 pounds. Moreover, although powered wheelchairs may change, it is anticipated that the weight will not increase substantially.

A combination of an attendant, a handicapped person and a powered wheelchair could yield loads up to 750 pounds. However, this combination is not considered an appropriate design standard. A heavy powered wheelchair could occupy most of the platform and not allow room for a person to stand on a lift. Also, a powered wheelchair provides independent movement and reduces the need for an attendant. Furthermore, some members of the Advisory Panel opposed anyone not in a wheelchair being on the lift.

2.3.2 Structural Safety Factor

The structural safety factor should be at least three (3) based on the ultimate strength of the construction material.

Rationale: In the "Safety Code for Elevators and Escalators," ANSI/ASME A17.1-1984, the design safety factor for structural components varies

depending on the function of the loaded member. They range from as high as 7.8 for bolts to as low as 2.2 for parts which are not considered critical from a safety standpoint. These safety factors are for elevators traveling at speeds far above those of a wheelchair lift and allow for emergency stops and high acceleration forces.

Mark's Standard Handbook for Mechanical Engineers, Eighth Edition suggests that good design practice calls for factors of safety of 1.5 to 4.0 based on yield strength of the material. The materials specified in ANSI/ASME A17.1-1984 have yield strengths of about one-half based on the ultimate strength, so the Mark's safety factor can be reconciled with the "Safety Code for Elevators and Escalators."

Recognizing that wheelchair lifts on transit vehicles are very slow moving relative to elevators, a design factor of three (3) has been designated for the lift. This is the same factor found in the California Administrative Code.

2.3.3 Useful Life

When used and maintained in accordance with manufacturer recommended procedures, a wheelchair lift structure should be designed to have a useful life equal to the useful life of the vehicle on which it is used.

Rationale: Once installed the lift becomes part of the vehicle. As with other components of the vehicle, the lift with normal maintenance, including repair and replacement of parts, should be operable as long as the vehicle. Useful life of a transit bus is 12 years. Useful life of smaller vehicles is less, with vans having a useful life of 3 to 5 years.

2.3.4 Materials

Structural components shall be made of steel or other durable construction material.

2.3.4.1 Ferrous surfaces should be either plated with a protective coating or be cleaned and have a corrosion and abrasion-resistant flat protective finish.

2.3.4.2 Nonferrous and nonmetallic surfaces should be coated using a durable finish.

2.3.4.3 Stainless steel does not require coating or surface treatment.

Rationale: The structural components of the lift are to have a useful life equal to that of the vehicle upon which they are mounted. Materials and coatings identified in these guidelines are intended to ensure this useful life. The discussions of the Advisory Panel included using a salt spray test or paint thickness measurement to insure compliance. The VA

standard includes both ferrous material coating and test methods. However, no specific tests or coating methods have been designated so that manufacturers can continue to use their preferred methods. Panel members considered placing any coatings or surface treatments on stainless steel unnecessary.

2.3.5 Interface with the Vehicle

2.3.5.1 Installation of the wheelchair lift should not reduce or in any way compromise the structural integrity of the vehicle and shall have a structural safety factor as specified in Section 2.3.2.

2.3.5.2 Attachment of the wheelchair lift, including any modification of the vehicle, should not cause an imbalance of the vehicle that will adversely affect vehicle handling characteristics.

2.3.5.3 No part of the installed and stowed lift should extend laterally beyond the normal width of the vehicle.

2.3.5.4 The lift should not contact the opened door and/or door frame during deployment and normal operation.

Rationale: The design of a wheelchair lift dictates the required space for installation. It should be the responsibility of the vehicle manufacturer to determine compatibility of his vehicle's structural design with the selected lift. These guideline specifications require that the interface with the vehicle should have the same design safety factor as the lift structure.

Interlocks that prevent lift operation unless a vehicle door is open are recommended. However, observations at public transportation operations indicated that door adjustments or improper lift installation can result in interference between the lift and the door. These specifications do not allow such operating conditions. Concurrently, these specifications encourage increased door clearances and/or more precision in lift operation. This specification does not prohibit the use of brushes or other devices that are designed to allow contact between the door and lift.

2.4 Mechanical and Hydraulic

Mechanical and hydraulic components include all parts of the lift drive or control systems that support the platform load during normal operation of the wheelchair lift.

2.4.1 Mechanical and Hydraulic Safety Factors

Mechanical and hydraulic components include all parts of the lift drive or control system that are subject to wear and degradation due to the operation of the lift.

2.4.1.1 The mechanical component safety factor should be at least six (6) based on the ultimate strength of the material.

2.4.1.2 Hydraulic components should comply with all applicable Society of Automotive Engineers Standards. These Standards include, but are not limited to the following.

SAE J 190 - Power Steering Pressure Hose - Wire Braided
SAE J 191 - Power Steering Pressure Hose - Low Volumetric
SAE J 514APR80 - Hydraulic Tubing Fittings
SAE J516JUN84 - Hydraulic Hose Fittings
SAE J517JUN85 - Hydraulic Hose

All other components that contain working fluid should have a minimum burst pressure of at least three (3) times normal design working pressure.

Rationale: The mechanical safety factor is in agreement with the California Administrative Code. Also, "Safety Standard for Manlifts," ANSI A90.1-1976 states that all parts of the machine shall have a safety factor of six (6) based on a full load. Although the wheelchair lift operates at a lower velocity and is subjected to less severe shock loads than a manlift, a safety factor of 6 is considered appropriate. The hydraulic system design guideline is structured to make use of applicable Society of Automotive Engineers Standards. Hydraulic components that are not the subject of SAE Standards should be burst pressure tested at least three times normal design working pressure to ensure the integrity of the complete hydraulic system.

2.4.2 Platform Free-Fall Limits

The platform loaded with the design load of 600 pounds should free-fall no faster than twice the normal descent rate in the event of any power or equipment failure during lift operation.

Rationale: Twice the normal decent rate stated in Section 2.5.10.1 is 12 inches per second. The California Administrative Code allows platform motion at up to 11.8 inches per second in normal operation and twice this speed in free-fall. Therefore, the free-fall speed specified here is approximately one half that of the California regulation. This reduced speed is still twice the normal speed of descent. The 12 inches per second was selected because this ratio seems achievable and safe. In addition, the Canadian Standards Association limits the free-fall rate of descent of the platform loaded to capacity (600 pounds) to 5 inches per second.

2.5 Control Systems

2.5.1 Control Unit

2.5.1.1 The control unit should be a console or box with a function switch, an operating switch, or a combination thereof. The control unit may also have a power switch.

2.5.1.2 The control unit location should allow the lift operator to have an unobstructed view of the platform during lift operation and should allow the lift operator to be on or off the vehicle during lift operation.

2.5.1.3 The control unit should be located in a position that minimizes its damage during use of the lift.

2.5.1.4 The control console should have simple instructions on or near it that directs the operator in the lift operating procedures.

Rationale: The control system should be simple. Operator error, a factor in lift accidents, can be reduced with simple control systems and instructions. Existing, popular active lift models do have easily understood controls that meet this requirement. Another safety factor is for the control unit to be located in a position that allows the lift operator constantly to monitor lift operations. Tethered or pendant-mounted control units are common in the industry but must be carefully positioned for both safe operation and long life. The position is especially important if a local operator uses the operating procedures in Section 2.2.6, Option B.

2.5.2 Control Power Switch

The lift controls should have a power switch with two positions--on and off. The "on" position enables lift operation. The "off" position prevents lift operation.

Rationale: The power switch must be on to operate the lift. This switch enables the function selection and the operating switches. This switch is considered important for the safe design of the control logic. The switch may be on the control unit. The switch may also be located elsewhere on the vehicle. For example, the switch may be activated by opening or closing the door that is used for the lift.

2.5.3 Control Functions

(Use one of the following optional sections)

Option A - Automatic Control

The complete wheelchair lift should be attendant operated, fully automatic, including folding and unfolding of the platform.

2.5.3.1 The lift control system should have at least four designated operating functions as defined:

(1) Up - raises a lift platform, while maintaining an operating position
(2) Down - lowers lift platform, while maintaining an operating position
(3) Fold - moves lift platform from an operating position to a stowed position
(4) Unfold - moves lift platform from a stowed position to an operating position.

2.5.3.2 The lift may have four additional optional functions as defined:

(1) Outer Barrier Up - raises outer barrier
(2) Outer Barrier Down - lowers outer barrier
(3) Inner Roll Stop Up - raises inner roll stop
(4) Inner Roll Stop Down - lowers inner roll stop.

Option B - Semi-Automatic Control

The complete wheelchair lift unit should be semiautomatic including a manual fold and unfold of the lift platform. The folding and unfolding of the lift from and to the stored position should be accomplished with not more than a 20-pound force.

2.5.3.1 The lift control system should have at least two designated operating functions as defined:

(1) Up - raises a lift platform, while maintaining an operating position
(2) Down - lowers lift platform, while maintaining an operating position.

2.5.3.2 The lift may have four additional optional functions as defined:

(1) Outer Barrier Up - raises outer barrier
(2) Outer Barrier Down - lowers outer barrier
(3) Inner Roll Stop Up - raises inner roll stop
(4) Inner Roll Stop Down - lowers inner roll stop.

Rationale: To help reduce driver error in fleets with different lifts, the operating terminology is standardized for both automatic and semi-automatic lifts. A distinction is made between recommended functions and optional functions. The recommended functions are considered the minimum acceptable for safe operation. Existing active lifts usually have an automatic barrier, and/or roll stop. The guideline allows an option for controlled barrier or roll stop operation.

It is important that durable markings identify the control functions. The durable markings help experienced operators and are vitally important when new or inexperienced operators are responsible for lift operation.

No nationally established standards for manual lifting exist. Ergonomists make judgements and recommendations for each type of manual lift that is encountered. The 20-pound force for folding and unfolding the semi-automatic lift platform is based on recognition that at and below this number the force is considered moderate. Ergonomists suggest engineering control, such as power assists, when a 20-pound lift force is exceeded.

2.5.4 Control Operating and Function Switches

2.5.4.1 The control system should consist of

(a) separate operating and function selection switches

or

(b) integrated operating and function switches.

2.5.4.2 The function selection switch or integrated switches should be labeled with the functions defined in Section 2.5.3.

2.5.4.3 The operating switch or integrated operating and function switches should require continuous force to operate the lift; and release of the switches shall stop lift motion.

2.5.4.4 The function selection switch or integrated operating and function switches should not allow the operation of more than one function at a time.

Rationale: The control system allows two approaches. The first is a function selection switch, which is used to designate a function, and an operating switch that activates the function. The second approach is separate integrated switches. Under this approach separate or combined switches (e.g. a single button "up" switch or a combined "up" and "down" toggle switch with a neutral position) control lift operation. Both approaches would be possible only by momentary switches that would stop lift movement when released. Also, for safety purposes the lift will only perform one function at a time.

2.5.5 Design Safety

The control system should be designed to be fail-safe for single failure modes that would negate the proper operations of the interlocks specified in Section 2.5.8. A complete failure modes and effects

analysis (FMEA) should be provided that demonstrates that this design requirement has been met.

Rationale: Safe operation is a primary concern of the guideline specifications. The safety protection for some operator errors and equipment failures resides in the integrity of the interlocks and safety features of Section 2.5.8. The safety of the lift/vehicle system is enhanced by requiring that the interlocks remain in a known safe state under conditions of any single failure of the control system or loss of power to the control system. An FMEA is a frequently used method in safety analysis to demonstrate what a design will do under selected failure modes. There are many reports and papers explaining FMEA. Three reports are:

(1) Dussault, N. B., "The Evolution and Practical Applications of Failure Modes and Effects Analyses," RADC-TRC-83-72, March 1983.

(2) MIL-STD-7858, Sept. 15, 1980, "Reliability Program for Systems and Equipment Development and Production," Task 204, Failure Modes, Effects, and Criticality Analysis (FMECA).

(3) ARP 926 A, "Fault/Failure Analysis Procedure," SAE Aerospace Recommended Practice", Rev. 11-15-79.

The first reference is a report that discusses several methods. The second reference is a Military Standard that is used in many defense system developments. The third reference is an SAE Recommended Practice used in the aerospace industry.

2.5.6 Jacking Prevention

The control system or inherent lift design should prevent the operation of the lift from jacking the vehicle and causing damage to the vehicle or the lift.

Rationale: To prevent damage to the lift or vehicle, the control system or inherent lift design shall not allow jacking. In some cases the release of load on the vehicle suspension when the lift platform reaches the ground is mistakenly considered jacking.

2.5.7 Manual Operation

The lift should have a manual method of operation permitting an operator to lower the platform to ground level from any position in its cycle with a wheelchair occupant on the platform. The manual method should also allow an unoccupied platform to be raised; and it should be possible to fold the lift to a service transport position. Barriers should be operable when the lift is in the manual mode.

Rationale: In the event of a power failure the lift must have a manual backup system to take passengers off the vehicle. Also, the manual operation would allow the lift to be stowed in order for the vehicle to move. For safety reasons the barriers should be operable.

2.5.8 Interlocks and Safety Features

2.5.8.1 Interlocks may (1) prevent vehicle movement or (2) provide a driver warning light; unless the lift is up and folded.

2.5.8.2 Interlocks may prevent lift activation and operation unless the vehicle is stopped and inhibited from moving and the appropriate door is open.

2.5.8.3 An interlock or inherent design feature should prevent stowing of the lift when the platform is occupied.

2.5.8.4 An interlock or inherent design feature should not allow a lift to move up or down when the platform is more than three (3) inches above the ground unless the outer barrier is raised and functioning.

Rationale: The interlock and safety features are designed to prevent unsafe conditions. The first interlock is advisory with an option. Although the vehicle movement feature is recommended, providing such an interlock for small vehicles is technically difficult and, therefore, raises the cost. This interlock is easier for vehicles with air brakes. The Advisory Panel did consider a warning light as a desired option to help prevent vehicle movement if the lift is unfolded.

The second interlock prevents lift movement unless the vehicle is appropriately inhibited from moving, and the lift can be deployed through an open door. This interlock reduces unsafe passenger conditions and damage to the lift or vehicle. The Advisory Panel debated the use of this interlock since it could cause problems in accident situations. It has been made optional, and, if used, must be designed with allowance for possible lift operation in emergency situations by people not familiar with lift details.

A potential safety hazard is a lift folding while a passenger is on it. This condition should be prevented by an interlock or by design (e.g., some existing active lifts have electric motors for stowing that have limited lifting capacity preventing stowing of an occupied lift).

Barrier failure also can create a very hazardous condition. To prevent this condition the lift shall not be able to operate up or down unless the outer barrier is raised.

2.5.9 Wiring

Wiring should be in accordance with SAE Recommended Practice SAE J1292 OCT 81 and referenced Standards, except when good engineering practice dictates special conductor insulations.

Rationale: This SAE Recommended Practice, "Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring," is accepted by the automotive industry and provides a baseline for design. The practice recognizes that unique design will require engineering practices that cannot be envisioned and incorporated into a recommended practice.

2.5.10 Lift Operational Requirements

2.5.10.1 The maximum speed of platform motion should be 6 inches per second. The operating time required to deploy the lift, lower or raise the platform, and stow the platform should not exceed 60 seconds.

2.5.10.2 The maximum platform horizontal and vertical acceleration should be 0.3g.

2.5.10.3 The maximum allowable jerk should be 0.3g/sec.

Rationale: Lift operating speeds and cycle times are set in the White Book as 5 seconds to deploy or stow and 15 seconds to raise or lower a passenger. Many transit operators consider this much too fast for the comfort and safety of the wheelchair occupant. The California Administrative Code allows platform motion at up to 11.8 inches per second. This rate was also considered fast by the Advisory Panel. The transit authority bid packages reviewed in developing these guidelines have specified speeds and velocities in a wide variety of ways. The speeds and operating times specified here are designed to be compatible with the existing conditions, be acceptable to the transit agencies and wheelchair occupant, and not place new design requirements on lift manufacturers.

"Safety Guidelines for Wheelchair Lifts on Public Transit Vehicles," UMTA-CA-06-0098-80-1 states that vertical and horizontal acceleration rates shall not exceed 0.3g and that jerk, the rate of change of acceleration, shall not exceed 0.3g/seconds throughout horizontal motion of the occupied lift platform. These rates are used in this guideline, but the Advisory Panel generally agreed that lower rates are desirable.

3.0 TESTING, CERTIFICATION, INSPECTION, AND WARRANTIES

3.1 Design Tests

The tests defined in Section 3.1 should be performed on one representative production unit of the wheelchair lift model purchased by this

procurement. Unless otherwise specified, the lift should meet the requirements given in Section 2.0 when attached to a fixture that simulates a bus installation and when supplied by electric, hydraulic, air, or other power source of output equal to that normally available on the bus. Only one representative production unit is required to be tested for certification, with all tests of Section 3.1 conducted on the same unit without any repairs or maintenance during the test other than that permitted by Section 3.1.11.

3.1.1 Durability Tests

The following tests should be performed without failure in the order given.

3.1.1.1 Vertical Cycling Tests. The lift platform should be operated up and then down through its maximum vertical operating range for 15,600 cycles with a load of 600 pounds for the first 600 cycles and 400 pounds for the remaining cycles. The ambient temperature for the first half of the cycles in each of these tests should be at least 110 F. The tests may be continuous or separated into groups of not less than 10 cycles with nonoperating periods of not more than one minute between each cycle in the group. The platform should raise and lower smoothly throughout the test with vertical and horizontal accelerations not exceeding 0.3g.

3.1.1.2 Deployment Cycling Test. The lift platform of an automatic lift should be folded and unfolded for 10,000 cycles. The ambient temperature for the first half of the cycles should be at least 110 F. The tests may be continuous or separated into groups and may have nonoperating periods between cycles as specified in Section 3.1.1.1.

3.1.1.3 Combination Vertical and Deployment Cycling Test. The tests in Sections 3.1.1.1 and 3.1.1.2 may be combined into a single test that meets the minimum requirements of both tests.

Rationale: The first two of the above tests are adapted from the California Administrative Code. Section 3.1.1.2 is only for automatic lifts. Since semi-automatic lifts do not have a power fold or unfold function, a durability test of fold and unfold is not necessary. Section 3.1.1.3 has been added to accommodate manufacturers equipped to conduct the tests simultaneously.

Note that the language in Section 3.1 does not mean that a manufacturer must perform these tests for each procurement. Once a production unit of a specific lift model and vehicle combination has been tested, the design tests apply to all procurements of that combination.

3.1.2 Low Temperature Operation Test

After 16 hours of exposure to a temperature not higher than 20 F, the wheelchair lift should be operated unloaded through 10 or more cycles of unfolding, lowering, raising, and folding (or lowering and raising for semiautomatic lifts) and through 10 or more cycles of raising and lowering with a 600-pound load. Each cycle should be separated by at least a 30-minute cooling period at a temperature not higher than 20 F. The lift should meet all performance requirements while operating at the exposure temperature.

Rationale: The above test is a modification of the low temperature test of the California Administrative Code. The major changes were to extend the soak time to correspond to an overnight storage at a low temperature, to add testing at the design load, and explicitly to require the lift to meet all performance requirements at the test temperature.

3.1.3 Platform Deflection Test

A static load of 400 pounds should be applied through the centroid of a test pallet placed at the centroid of the platform. The platform should be raised and lowered with this weight. During the lift operation the platform should not deflect more than three degrees in any direction from the loaded position and its unloaded position.

Rationale: Section 3.1.3 has been adapted from the California Administrative Code, which has a platform deflection requirement and from the VA specifications. For these guideline specifications, platform deflection has been defined in terms of test requirements.

3.1.4 Self-Damage Tests

The controls should be held in operating position for 5 seconds after the unloaded lift meets resistance to its travel under each control position with any limit switch disabled. The test should be performed twice at each lift position of unfold, fold, full up at floor level, and full down at ground level.

Rationale: Section 3.1.4 is adapted from the California Administrative Code.

3.1.5 Power and Equipment Failure Test

A failure of power, chain cable, hydraulic hose, or air hose that allows the lift to deploy or the platform to lower should be simulated. The wheelchair lift should comply with Section 2.4.2 during this test. An FMEA may be provided in lieu of conducting actual tests.

Rationale: Section 3.1.5 has also been adapted from the California Administrative Code. It has been modified by allowing an FMEA to be used in place of actual testing. Such an analysis examines the consequences of failures such as those specified for simulation.

3.1.6 Outer Barrier and Outer Barrier Roll Stop Tests

3.1.6.1 Outer Barrier Test (For Section 2.2.6, Option A)

The contractor should test the ability of the outer barrier to retain a powered wheelchair. Two of four wheelchairs are to be tested. The Everest and Jennings 3M Marathon or the Invacare Power Rolls Arrow Model 4M929E and the Everest and Jennings Modular Power Chair 61 or the Fortress Scientific 655 should be used. The two wheelchairs and secured load should not leave the platform and the outer barrier should not be defeated (driven through or climbed over) by the wheelchairs when tested under all of the following conditions:

(a) fully charged battery system
(b) equivalent occupant loads of both 110 and 250 pounds
(c) operated both forwards and backwards
(d) accelerated at full power from a starting position off of the lift platform and a minimum of 48 inches between the front edge of the foot rests or rim of the rear tires and the outer barrier
(e) a platform positioned with a 8 degree outward slope
(f) the lift platform in a raised position.

The Everest and Jennings 3M Marathon or Invacare Power Rolls Arrow Model should be equipped with a standard adult size seat, standard foot rests, 20-inch rear wheels, eight-inch front casters, and a standard upright back. The Everest and Jennings Explorer Modular Power Chair or the Fortress Scientific 655 should be equipped with all the above features except that the front and rear tires should be 10 inches in diameter and the seating option and batteries should result in a gross wheelchair weight at or exceeding 210 pounds.

3.1.6.2 Outer Roll Stop Test (For 2.2.6, Option B)

A static load of 1600 pounds should be applied at a height of three (3) inches above and parallel to the wheelchair ground plane, evenly distributed over the full width of the outer roll stop device. The load will be applied for at least five (5) seconds with the lift platform at the floor level and also will be applied as the wheelchair ground plane moves down (or up). A load of 600 pounds will be on

the lift during the test if the wheelchair retaining operation is dependent on such a load for its proper operation.

3.1.6.3 Inner Roll Stop

The contractor should test the ability of the inner roll stop to prevent a wheelchair from inadvertently rolling off the platform. In its raised position the roll stop should withstand a total force of at least 300 pounds parallel to the platform surface in the unloading direction. The force should be applied at a minimum height of 2-1/2 inches above the top surface of the platform with 150 pounds at each of two points 11.8 inches on each side of the center of the roll stop. Inherent design features may preclude the need for an inner roll stop.

Rationale: The four wheelchair models represent current wheelchairs that are powered and could override barriers. They have been selected because they have been identified as representing those models that are currently available and produce high and possibly the highest amounts of force that could overcome a barrier.

Specific models of wheelchairs have been chosen to standardize this test and to make transit operators aware of the limits of the test. A transit operator faced with transporting wheelchairs more powerful than those mentioned (e.g., specially-adapted wheelchairs) will be faced with different safety and risk levels.

The wheelchairs are to be tested with two different weights. The 110-pound represents a 5th percentile woman. With this lighter load, a wheelchair would be more susceptible to climbing or bouncing over a barrier. The 250-pound load represents a 99th percentile male, the standard used in defining the design load. The heavier weight will test the ability of a wheelchair to be powered through a barrier.

The 48-inch distance is longer than the minimum allowable platform length and less than the combined platform length and interior clear distance found on the same bus models. The 48 inches is considered a reasonable test distance.

Section 3.1.6.1 (Option B) tests the outer roll stop under Option B of Section 2.2.6. The test is an adaption of the test required by the VA.

The inner roll stop test specified in Section 3.1.6.2 is adapted from that currently required for an outward barrier under the California Administrative Code. This test appears designed to prevent inadvertent rolling off of a platform. The 2-1/2-inch test height requires a minimum roll stop height of 2-1/2 inches. This is the same height required by the CSA. The California Administrative Code and the VA require minimum roll stop heights of 3 inches or more. VA tests showed that under simulated lift conditions, a wheelchair could roll over a 2-inch barrier but

be stopped by a 3-inch barrier. The 2-1/2-inch barrier is accepted by CSA and corresponds to the height at which clear length is measured (see Section 2.2.1.2). This test applies for inner roll stops under both Option A and Option B discussed in Section 2.2.6.

3.1.7 Static Load and Interface Test

A static load of 1800 pounds should be applied through the centroid of a test pallet placed at the centroid of the platform when the platform is positioned at its raised position. The length and width dimensions of the test pallet should be 24 inches by 24 inches to correspond to the approximate outer dimensions of a wheelchair "footprint." The load should remain on the platform not less than two (2) minutes. After the load is removed, an inspection should be made to determine if fracture has occurred.

Rationale: Section 3.1.7 is adapted from the California Administrative Code. It was modified to specify a time period for the test. The two-minute period is the same as that specified by the VA.

3.1.8 Vehicle Interface Test

This test should be or should have been conducted on a lift installed in an actual vehicle model being purchased through this procurement. A static load of 900 pounds should be applied through the centroid of a test pallet placed at the centroid of the platform when the platform is positioned at its raised position. The length and width dimensions of the test pallet should be 24 inches by 24 inches. The load should remain on the platform not less than two (2) minutes.

Rationale: Section 3.1.8 has been developed for these guideline specifications and tests the structural interface between the vehicle and the lift. This test need be done once for each lift-vehicle model combination.

3.1.9 Interlock Safety Tests

The contractor shall submit a test plan for approval by the Procuring Agency or a statement of certification that demonstrates that the lift meets the safety related interlocks as given in Section 2.5.8. The test results or certification should be based on a lift installed in a vehicle of the same make and model of that being procured through this bid package.

Rationale: The test plan or certification of a design test will demonstrate the level of safety provided by the lift interlocks. The results of a previous test, which are certified, can be used if that test had been conducted on the vehicle make and model being procured.

3.1.10 Visual Inspection

At the conclusion of any test described in Section 3.1--except Sections 3.1.6 and 3.1.7--with all loads removed, the parts of the wheelchair lift should show no condition of fracture, permanent deformation, wear that would exceed manufacturer's tolerances, perceptible impairment, or other deterioration that would be dangerous.

Rationale: Section 3.1.10 is adapted from the California Administrative Code. Extreme wear implies that point where a component or part shows wear that would indicate failure before its design life.

3.1.11 Maintenance During Tests

During the Durability Tests of Section 3.1.1, the inspection, lubrication, maintenance, and replacement of parts (other then bulbs and fuses) may be performed only as specified in the contractor's maintenance manual for the lift and at intervals no more frequent than specified in the manual. Maintenance specified for certain time intervals should be performed during the vertical cycling and deployment cycling tests at a number of cycles that is in the same proportion to the total cycles as the maintenance period is to 36 months.

Rationale: Section 3.1.11 is adapted from the California Administrative Code. Scheduled maintenance is permitted during the tests, and parts scheduled for replacement can be replaced. However, if replacement or other parts fail, the test would have to be repeated.

3.1.12 Testing Certification

The contractor should provide written certification of compliance of the tests specified in Section 3.1, Design Tests.

Rationale: This is a standard practice in design testing.

3.2 Acceptance Test or Inspection (Optional)

The contractor should submit for approval to the Procuring Agency a plan to demonstrate that the lifts purchased by this procurement meet the requirements given in Section 2.0, unless otherwise tested in Section 3.1. A mutually agreed upon notification time prior to the conduct of any test should be made between the two parties. The test or inspection results should be recorded and witnessed and submitted to the Procuring Agency as proof of meeting the acceptance criteria of the approved acceptance inspection.

Rationale: This section is optional since most lifts would be purchased as a part of a vehicle procurement and any lift acceptance inspection or testing would be included in the vehicle acceptance testing.

3.3 Installation Certification

The contractor should submit written certification that the lift has been installed according to lift or vehicle manufacturer specification.

Rationale: Section 3.1.8 describes a design test for installation. The requirement in Section 3.3 is to ensure that the fleet installation has been satisfactorily accomplished for the actual vehicles procured. Even though vehicle manufacturers do not normally specify how a lift should be installed, it is important that the lift installed not violate vehicle manufacturer specifications for vehicle performance, safety, and life.

3.4 Warranty

A statement of warranty should be provided with each lift assuring the quality of materials and workmanship of the product for at least one (1) year from the date of acceptance by the final consumer.

Rationale: The above is based on warranty provision found in the VA specifications.

SECTION 4.0, MAINTENANCE, TRAINING, AND SERVICE, IS ADAPTED FROM THE WHITE BOOK SPECIFICATIONS. IT IS NOT NECESSARY IF THESE CONDITIONS ARE COVERED BY GENERAL CONDITIONS OF THE PROCUREMENT PACKAGE.

4.0 MAINTENANCE, TRAINING, AND SERVICE

4.1 Documents

The contractor should provide ---(*)--- current maintenance manual(s), ---(*)--- current parts manual(s), and ---(*)--- operator's manual(s), or ---(*)--- combination manual(s) thereof as part of this contract. The contractor should keep maintenance manuals available for a period of three (3) years after the date of acceptance of the lift procured under this contract.

(*) Procuring Agency to fill in number of manuals to be provided.

4.2 Maintenance and Inspection

Scheduled maintenance or inspection tasks as specified by the contractor should require a skill level of 3M or less. Scheduled maintenance tasks should be related and should be grouped in maximum bus mileage intervals. Routine scheduled maintenance actions, such as lubrication and adjustments, should not be required at intervals of less than 6,000 bus miles or 1,000 up and down lift cycles, whichever comes first, except for routine daily service performed during the fueling operations. Higher levels of scheduled maintenance tasks should occur at even multiples of the vehicle mileage for lower level tasks.

4.3 Maintenance Accessibility

All systems or components serviced as part of the periodic maintenance of the lift, whose failure may cause a safety hazard or a roadcall, shall be readily accessible for service and inspection. To the extent practicable, removal of physical movement of components unrelated to the specific maintenance and/or repair tasks involved should be unnecessary. Relative accessibility of components, measured in time required to gain access, should be inversely proportional to frequency of maintenance and repair of the components.

4.4 Training (Optional)

The contractor should have at least one qualified instructor who should be available at the Procuring Agency's property for ---(*)--- calendar days between the hours of ---(*)--- and ---(*)--- after acceptance of the first lift. Instructor(s) should conduct classes and advise the personnel of the Procuring Agency on the proper operation and maintenance of the lift. The contractor should also provide visual and other teaching aids for use by the Procuring Agency's own training staff.

(*) Procuring Agency to fill in pertinent information

Rationale: For small procurements this type of training would be expensive and excessive. This section is, therefore, optional. For small procurements the contractor should be requested to provide brief instructions on lift use at the time of vehicle delivery.

4.5 Service

4.5.1 Engineering

The contractor should, at its own expense, have a competent engineering representative(s) available on request to assist the Procuring Agency's staff in the solution of engineering or design problems within the scope of these specifications that may arise during the warranty period. This does not relieve the lift contractor of responsibilities under Section 3.4, Warranty.

4.5.2 Spare Parts

The contractor shall guarantee the availability of replacement parts for lifts procured under this contract for at least a period equal to the useful life of the lift. Spare parts shall be interchangeable with the original equipment and shall be manufactured in accordance with the quality assurance provisions of this contract.

COMMENTS SHEET

These guideline specifications are an industry document developed by professionals familiar with accessible transportation. The document is considered to be an important step in the evolution of accessible transportation. However, it is not the final step. It is anticipated that operational experiences and technology advancements will indicate areas where these guidelines can be improved. Your comments and suggested changes are solicited. Please use this comments sheet to forward your comments to:

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Comments: (When referring to specific sections of the guideline specifications, please identify the section number and title.)