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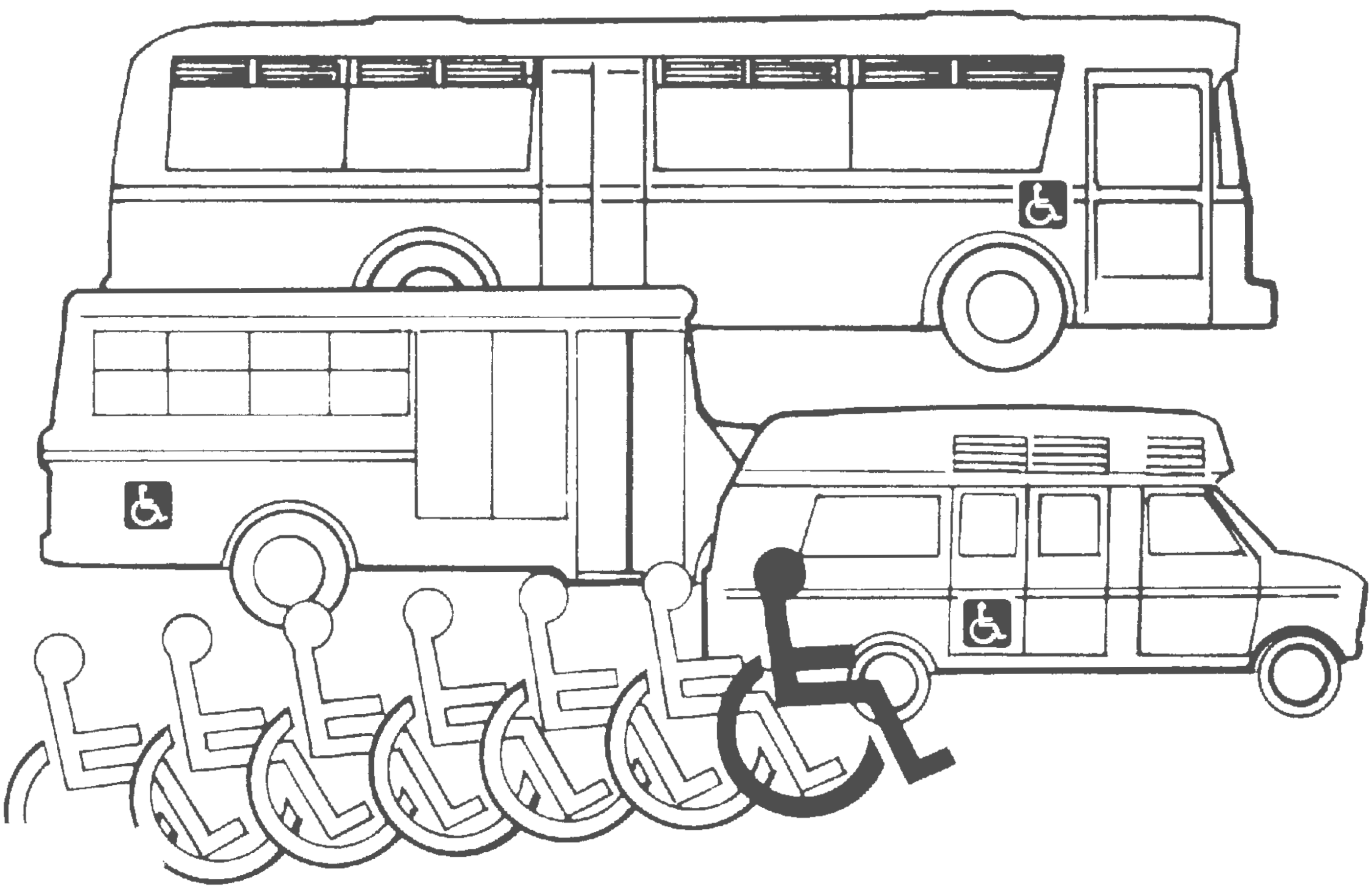
National Workshop on Wheelchair Accessibility

Guideline Specifications for Passive Wheelchair Lifts

U.S. Department of Transportation
Urban Mass Transportation Administration

Office of Technical Assistance
Office of Bus and Paratransit Systems

May 7–9, 1986



UMTA Technical Assistance Program

National Workshop on Bus-Wheelchair Accessibility

Guideline Specifications for
Passive Wheelchair Lifts

May 7-9, 1986
Seattle, Washington

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Prepared for
Office of Bus and Paratransit Systems
Urban Mass Transportation Administration
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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.

Mr. Tom Bonnell, The Braun Corporation, Winamac, Indiana

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Mr. Dennis Cannon, Architectural and Transportation Barriers Compliance Board, Washington, D.C.

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Ms. Mary Lou Daily, Metropolitan Boston Transit Authority, Boston, Massachusetts

Mr. James Elekes, New Jersey Transit, Maplewood, New Jersey

Ms. Pat Flinchbaugh, York Transportation Club, York, Pennsylvania

Mr. Robert Garside, Regional Transportation District, Denver, Colorado

Mr. Howard Hall, California Department of Transportation, Sacramento, California

Mr. William Henderson, Senior Services of Snohomish County, Everett, Washington

Mr. Greg R. Hill, General Motors Corporation, Pontiac, Michigan

Mr. Steve Holmstrom, Aeroquip Corporation, Jackson, Michigan

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Mr. Frank Kirshner, Southern California Rapid Transit District, Los Angeles, California

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Ms. Fran Lowder, METRO Citizen's Advisory Committee, Arlington, Virginia

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1.0 GENERAL

1.1 Scope

These guideline specifications relate to passive lifts that are used by handicapped individuals to assist in boarding public transportation vehicles. A passive lift is defined as a lift that when stowed allows the unimpeded use of the vehicle door in which the lift is located. These guidelines 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 the 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 vehicle 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.

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

Deploy - The term used to denote the operation of a lift from a stowed position to an operating position.

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.

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 shall 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.

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.

Stow - This term denotes the movement of a lift from an operating position to a position where the lift is stored and does not interfere with passenger use of entrance.

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

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 guideline.

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 "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, Vol. 53, pp 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 (49 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 temperature ranges 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 bus. Since existing lifts reportedly meet these requirements, the weights of existing lifts are considered acceptable. The recommended upper limit is 3,000 pounds, which does not exclude any existing model.

2.1.3 Operation Constraints

2.1.3.1 The lift should operate when the lift platform is level and on any angle up to five (5) degrees or 8.7 percent in both the longitudinal and transverse direction.

2.1.3.2 The lift should be deployable when the curb levels are at least three and one-half (3-1/2) inches below the first step of the vehicle, the vehicle is on level ground, and and the vehicle is at the manufacturer's specified ride height.

Rationale: A lift will operate in a variety of different topographical conditions and must do so safely and reliably. This specification identifies a balance between the topographical conditions to be accommodated by the lift design and the conditions where a lift will not be required to operate. In this latter case a bus stop zone would be considered inaccessible unless changes were made (e.g. a platform or pad installed at the bus stop zone) that allowed lift operation.

No specification reviewed during the development of these guidelines identified any requirements in terms of the roll of the bus. The VA sets an operational limit of 9 degrees in any direction of tilt for the maneuvering of a powered wheelchair. A seven (7) percent grade specification is currently used by Seattle Metro in its lift procurement. Since a fully loaded lift can tilt up to 3 degrees (see Section 2.2.5), the 5 degree parameter was chosen in order to be less than the 9 degree limit when the 3 degree tilt is considered. The three and one-half (3-1/2) inch distance above a curb in Section 2.1.3.2 can be met by existing lifts.

This section is advisory. It has been included to provide a design guide for manufacturers. Concurrently, it can be used by transit operators to help define inaccessible bus stops. These guidelines do not assume the wheelchair lift will operate in all topographical conditions. Some current stops of a transit operator may be inaccessible. The transit operator would have to change the topography of the stop or change its location to provide accessibility.

2.1.4 Boarding Direction

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

Rationale: The Advisory Panel considered outward facing to be the recommended position. However, emergency or other factors may require inward facing. For example, the ability to maneuver inside the bus or at a bus stop may require a person in a wheelchair to use a lift in either direction. To accommodate the passenger, the lift needs to be able to accept and operate with a wheelchair facing either inward or outward.

2.1.5 Location of Lift (Use one of the following options)

(Option A) The lift should be installed in the front door of the bus.
(Option B) The lift should be installed in the rear door of the bus.
(Option C) The lift should be installed in either the front or rear door of the bus.

Rationale: The issue of lift location generated many comments from advocates of either front door or rear door lifts. The location of the lift is a local decision based on local conditions. No location is universally agreed to be better than another. A transit operation should assess several factors before specifying a lift location, since doing so can exclude certain bus manufacturers from bidding. If a clear preference is not evident, the location should be optional.

Among the factors to be considered are the following:

Accident Data - Accident data from different sources supported both front door and rear door locations. A transit operation should assess its own accident history in terms of accidents involving front or rear door operation.

Bus Stop Topography - Positioning a lift for use is affected by bus stop topography. Vehicle maneuverability requirements at a bus stop differ between front and rear door lifts.

Operating Policies - A driver must leave his seat to operate current rear door lifts. Current operating policies or labor rules may prohibit such actions and would need to be changed.

Communication with Driver - Better communication between the driver and the mobility limited passenger is possible when the wheelchair securement is located near the front of the vehicle.

Interior Maneuverability - On some vehicles wheelchair maneuverability in the front of a vehicle can be restricted by fare boxes or other items. Rear door entry is normally not as restricted.

Dwell Time - The dwell time at a bus stop can be affected by the location of a lift. As noted above, a driver must leave his seat to operate current rear door lifts. However, the location and type of securement device and the interior maneueverability can also affect dwell time. Properly positioned securement devices may require less time when associated with a rear door lift. Thus, in terms of dwell time the lift location must be considered with regard to other factors.

Lift Dimensions - Some buses can accommodate larger lifts in the rear door. Specifying wider lifts may force some manufacturers to offer a rear door lift.

<u>Fare Collection</u> - The fare box on a transit vehicle is almost always in the front. Rear door boarding requires different fare collection procedures.

<u>Current Lift Location</u> - If a transit property currently has front or rear door lifts, it may find it advantageous to procure more of the same. For example, if a transit operator has invested in pads or made other bus stop improvements based on current lift location, procuring vehicles with a different lift location might require more bus stop improvements. Mixed lift locations also put extra demands on passengers and drivers.

2.1.6 Warning Signals

2.1.6.1 When the lift is being deployed, the lift should have an audible warning signal of 85 dBA (as measured five feet outside the door of the vehicle).

2.1.6.2 When the lift is being deployed, operated, or stored, the four-way flasher, hazard lights on the vehicle should be operating automatically.

Rationale: Transit operators report that lift accidents involve both persons using and not using the lift. The audible warning will signal passengers at a bus stop that the lift is being deployed. The 85 dBA level is a frequently used level for annunciators. A person can be exposed to this sound level for long periods of time without hearing damage; and the level is loud enough that it can be heard above normal background noise.

The four-way flasher, hazard lights will serve as a visual signal that the lift is being deployed. Since lift operation adds to the dwell time at a bus stop, the visual signal will alert motorists that the bus will be stopped for a longer than usual period. Although this requirement adds costs that could be avoided with an operational policy that drivers activate the hazard signals, to avoid human error the guidelines specifications require automatic warning lights.

2.1.7 Maximum Noise Level

The operating noise level of the lift should not exceed 75 dBA inside the vehicle or on the lift platform, except for the audible warning signal as specified in Section 2.1.6.1.

Rationale: The lift operation should not audibly disrupt the transit operations nor should it obscure the warning signal. The 75 dBA level has been used by the San Diego Transit Corporation in its lift specifications and has been adopted for use in these guidelines.

2.1.8 Protective Covering

2.1.8.1 **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.**

2.1.8.2 **All exposed edges or other hazardous protrusions on the wheelchair lift should be protected to minimize injury during lift operation and in case of accident.**

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

2.1.9 Operation Counter (Optional)

The lift may have an operations or use counter that records each complete cycle of the lift.

Rationale: A counter can 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. Local operating practices would determine whether it should be an option. The additional cost of this item may be offset by lower operating costs resulting from more timely maintenance.

2.1.10 Power Source Interface

The lift should operate and meet all requirements of these specifications while using the electrical and/or hydraulic power sources normally used on public transportation vehicles. The lift should meet these requirements whenever those power sources are performing within their specified ranges. The lift should continue to meet the requirements of Sections 2.4.2, 2.5.5, 2.5.8, and 2.5.11 during and following power source transients, including failure, that may be experienced on transit vehicles.

Rationale: The electrical and hydraulic interface between the vehicle and the lift is an important consideration in lift performance. This guideline is intended to ensure both proper interface consideration for normal operations and safe lift conditions in abnormal situations.

The guideline specifications have been developed for passive lifts and diesel buses. Although much of the guideline specifications could be

used for other modes of transit, not all sections would apply. This is especially true for this section relative to trolley buses. The power source of a trolley bus places special requirements on the power source interface between the lift and the vehicle. A transit property planning to purchase lifts for use in trolley buses may have to add other power source interface requirements.

2.2 Platform

2.2.1 Dimensions

2.2.1.1 The lift platform should have a minimum clear width of 28-1/2 inches. It is desired to have a minimum clear width of 32 inches.

2.2.1.2 The minimum clear width between any handrails at the height of 14 inches or more above the platform surface should be 31 inches. It is desired to have a minimum clear width of 35 inches.

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

Rationale: Current passive lifts have overall widths of 30 to 42 inches and lengths of 40 to 47 inches. Barriers, roll stops, and handrails, can reduce the effective clearance below these dimensions.

The effective length of wheelchairs includes the length added by footrests, which means wheelchairs are shorter at ground level than at footrest level. Section 2.2.1.3 recognizes this fact by specifying a minimum platform length and a minimum clear width at a distance of 2-1/2 inches above the platform.

Estimates on 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

Percentile	Invacare Length	Invacare Width	1986 Everest & Jennings Length	1986 Everest & Jennings Width	1987 Everest & Jennings[(1)] Length	1987 Everest & Jennings[(1)] Width
100/99	48	30	77-1/2[(2)]	28-1/2	47	31-7/8
99			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	
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 the width of the vehicle doors and the floor height. The following table presents examples of these dimensions found on buses sold in the United States:

Door and Floor Height Dimensions for Selected U.S. Standard Size Buses

Examples of Typical U.S. Standard Size Buses	Door Width[(1)] Front Door	Door Width[(1)] Rear Door	Floor Height Front Door	Floor Height Rear Door
Flxible Corporation-Metro	36 in.	30 in.	30 in.	34.9 in.
General Motors Corp.-RTS 04	30 in.	44 in.	32 in.	35.75 in.
Neoplan- T-Drive ADB	34.5 in.	34.5 in.	31 in.	37 in.
Scania-CN112	48 in.	26 in.	31 in.	34 in.

(1) Door width is metal to metal. Clear widths would be less allowing for handrails and other elements.

Although the vehicle dimensions affect the size of the lift, within the specified minimum dimensions 90 to 95 percent of the wheelchair population can be accommodated. The dimensions in this guideline represents a realistic balance between the design limitations of current bus equipment 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 recommended dimensions assume adequate interior maneuverability within the vehicle. Limited maneuverability on the vehicle could require a wider lift to allow acceptable access.

"Desired" dimensions are included in these guideline specifications. A user of these guidelines could provide cost offsets or other considerations for bidders providing lifts that meet or exceed the "desired" dimensions. The "desired" dimensions also represent the consensus of the Advisory Panel in terms of the desired direction for the industry. In the future, lifts should have minimum widths of 32 inches and minimum lengths of 44 and 48 inches.

The clear width between handrails is designed for the maximum width of wheelchair and allowance for a person to have clearance for hands on the rims of a wheelchair.

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 for people standing on the lift and provides traction for a wheelchair.

2.2.3 Protrusions

When the lift barrier or roll stop is down, the platform should have no protrusions from the surface greater than 1/4 inch vertical rise or 1/2 inch smooth transition rise (slope no greater than 1:2).

Rationale: When lift barrier or roll stop is down, movement on and off the platform should be easy and not inhibited by protrusions greater than 1/4 inch vertical rise or 1/2 inch smooth transition rise from the surface. These dimensions are adapted from the UFAS.

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

2.2.4 Gap Dimensions

When a lift is in the loading position at the vehicle floor height, the gap between the lift platform and the vehicle floor should be at a minimum. In no case should the vertical distance exceed 5/8 inch and the horizontal distance exceed 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 virtually no gap.

2.2.5 Platform Deflection

The lift platform should not deflect more than three (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 Administration Code.

2.2.6 Edge Guards, Outer Barrier and Inner Roll Stop

2.2.6.1 Edge guards should extend the length of the platform that operates outside of the vehicle. These edge guards should have a minimum height of one inch.

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

2.2.6.3 The outer barrier 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 a part of the vehicle as an inner roll stop. The inner roll stop 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 should be designed to meet the test requirements of Section 3.1.6.2.

2.2.6.6 The contractor should identify and clearly emphasize in the operations and maintenance manuals any barrier or roll stop adjustment or maintenance action 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 edge guards are not in the direct path of a wheelchair using a lift, they are not designed to retain a wheelchair in direct forward or reverse motion but are designed to deflect tire direction. The one-inch height corresponds to that found in the California Administrative Code.

In 1985, Garrett Engineers, Inc. conducted tests for the Southern California Rapid Transit District (SCRTD). These tests showed that outer barriers on all existing passive wheelchair lifts could be overcome by commonly available powered wheelchairs. The powered wheelchairs could ride over the outer barriers or push them down. SCRTD initiated these tests following an accident investigation that indicated a powered wheelchair had defeated an outer barrier.

The unsafe condition of an outer barrier not retaining a wheelchair on the platform is unacceptable. This guideline is intended to eliminate this unsafe condition. The tests described in Section 3.1.6.1 establish the limits for barrier operation.

The Advisory Panel considered having the same requirements for an inner barrier. However, transit operators reported no problems with the existing inner roll stop. Also, the accident scenarios involving running over the inner roll stop or off the inside of a lift appeared to involve less risk of serious injury. Given these conditions, the Advisory Panel considered the requirements of a inner "barrier" to be different from an outer barrier. The inner roll stop is designed to stop inadvertent rolling of a wheelchair and provide an acceptable margin of safety.

It is recognized that certain lift designs may obviate the need for a separate inner roll stop by using a solid part of the vehicle structure as the inner roll stop. In such a case, the vehicle structure will function as the inner roll stop.

2.2.7 Handrails

2.2.7.1 When the lift if fully deployed, the platform should be equipped with a handrail on each side of the lift.

2.2.7.2 The handrails should be 25 to 34 inches above the platform and should be a minimum 12 inches in length.

2.2.7.3 The handrails should be capable of withstanding a horizontal force of 100 pounds concentrated at any point without permanent visible deformation.

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

2.2.7.5 **For wheelchair lifts that move in a arc motion, handrails should move with the lift. For wheelchair lifts that are of an elevator type, the handrails should be stationary or move with the lift.**

Rationale: For a person with mobility only on one side, two handrails allow boarding in either direction. Handrails on both sides of a lift also limit lateral wheelchair movement.

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. However, stationary handrails currently in use have not been reported to be a major problem. The Advisory Panel considered movable handrails preferable for arc lifts. For elevator lifts stationary or movable handrails were considered acceptable.

The vertical height dimensions and the 100-pound force requirement are adapted from the Canadian Standards Association standard.

2.2.8 Platform Lighting

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

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.

2.2.9 Platform Markings

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.**

2.2.9.2 **The lift may have a designated standing area for lift passengers who are not in a wheelchair.**

Rationale: The marking of the platform edges will provide greater visibility and reduce the potential for accidents. When standees are allowed on a lift, a designated standing area may be desirable. This standing area would be designated in a location to provide the passenger enhanced safety when using the lift.

2.2.10 Platform Seating (Optional)

Mobility limited passengers who are not in a wheelchair should be provided a seat that enables them to be in a seated position when using the lift. The seat when not in use will not interfere with normal lift operations or decrease the available clear space below the minimum identified in Section 2.2.1. The seat should be capable of holding a 95th percentile male and the force required to position the seat should not exceed five (5) pounds.

Rationale: The option allows transit operators to provide extra comfort and safety for a person not in a wheelchair who is using the lift. When using the seat, a passenger will have better head clearance and better stability on the lift. The Advisory Panel considered that this seat was optional and that the need for a seat was influenced by the type of lift. With the movement of an arc lift, a seat may provide a passenger with more of a sense of safety. On an elevator type lift, the lift movement reduces the need for a seat to provide perceived safety.

2.3 Structural

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.

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 weights 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 approaching 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.

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 that 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 selected. 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 a part of the vehicle. As with other components of the vehicle, the lift with manufacturer recommended maintenance, including repair and replacement of parts, should be operable as long as the vehicle. Useful life of a standard size transit bus is 12 years.

2.3.4 Materials

Structural components should 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, primed, and have a corrosion and abrasion resistant flat finish.

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

2.3.4.3 Stainless steel does not require coating or surface treatment.

Rationale: The structural components of the lift should have a useful life equal to that of the vehicle upon which it is mounted. The materials and coatings identified in these guidelines are intended to ensure the useful life. Discussions of the Advisory Panel included using a salt spray test or paint thickness measure to ensure compliance. No specific tests have been designated in order to allow manufacturers flexibility, recognizing that the overall goal is to have materials lasting the useful life of the vehicle.

2.3.5 Interface with the Vehicle

2.3.5.1 The interface with the vehicle should have the structural strength required for in situ static loading of the lift platform to 1,800 pounds (three times the lift capacity).

2.3.5.2 Installation of the wheelchair lift should not reduce or in any way compromise the structural integrity of the vehicle.

2.3.5.3 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.

2.3.5.4 No part of the installed and stowed lift should extend into the stepwell, laterally beyond the normal side contour of the vehicle, or in any way violate the specified approach or breakover angle of the vehicle.

2.3.5.5 The stowed lift should not inhibit the operation of the vehicle door; and there should be no contact or rubbing between the opened door and/or the door frame that would damage the door or the lift during deployment and normal operation of the lift.

Rationale: The structural safety factor of the lift is three (3) and the designated lift capacity is 600 pounds. This section requires that the lift interface with the bus have the same design safety factor as the lift structure.

The design of a wheelchair lift dictates the required space for installation. The bus manufacturer has the responsibility to determine compatibility of the bus structural design and the selected lift.

Protrusions both inside and outside the bus pose potential hazards for passengers. The potential of damage to the lift is also increased when parts of the lift protrude outside the bus. Section 2.3.5.4 prohibits protrusions in the stepwell or on the sides of the bus. Also, the lift should not protrude from underneath the bus and adversely affect the

approach or breakover angles. This requirement includes protrusions that result from the drifting of the lift. Drifting should be prevented through lift design, mechanical lock or detent.

Interlocks that prevent lift operation unless a vehicle door is open are included in these guideline specifications. Observations at public transportation operations indicated that door adjustments or improper lift installation can result in interference between the lift and the door. This guideline specification does not allow such an operating condition. Concurrently, it encourages increased door clearances and/or more precision in the lift operation. The 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 system that are subject to wear and degradation due to the operation of the lift.

2.4.1 Mechanical and Hydraulic Safety Factors

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 All hydraulic hoses should comply with SAE Standards J190 (Power Steering Pressure Hose--Wire Braided) and J191 (Power Steering Pressure Hose--Low Volumetric Expansion Type).

2.4.1.3. All components that contain hydraulic fluid should have a minimum burst pressure of five (5) times normal design working pressure.

Rationale: The mechanical safety factor is in agreement with the California Administrative Code. Also, "Safety Standards 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 it should be subjected to less severe shock loads than a manlift, a safety factor of 6 is considered appropriate.

The hydraulic safety factors are based on SAE standards for hose and ANSI/ASME A17.1-1984, Safety Code for Elevators and Escalators, Part III Hydraulic Elevators. Part III requires safety factors of 5 on hydraulic cylinders, piping, and valves.

2.4.2 Platform Free Fall Limits

The platform loaded with the design load should free-fall no faster than twice the normal descent rate, as specified in Section 2.5.11.1, in the event of any power or equipment failure during lift operation.

Rationale: Twice the normal descent rate stated in Section 2.5.11.1 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.

2.4.3 Hydraulic Power Source (Use one of the following options)

(Option A) **The hydraulic power source for the lift should be the vehicle power steering pump or another existing hydraulic power source on the vehicle.**

(Option B) **The lift hydraulic system shall be independent and shall operate the lift ---(*)--- percent of design speeds at a minimum temperature of ---(*)--- F.**

*** To be completed by Procuring Agency.**

Rationale: Cold weather affects the operation of the hydraulic systems on current lifts. Where cold weather is not a problem, Option A can be used in lift specifications. When cold weather conditions are expected to affect the operation of the lift, Option B can be used to specify an independent hydraulic system that will function in cold weather. This separate system could be driven by the power steering pump.

2.5 Control Systems

2.5.1 Control Console

2.5.1.1 **The lift controls should be located on a console and shall consist of a power switch, a function selection switch, and an operating switch.**

2.5.1.2 **The control console should be located in a position where the lift operator (driver) has a direct unobstructed view of the platform during lift operation and should be secure from operation or tampering by unauthorized individuals.**

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

2.5.1.4 The switches on the control console should by their location or by other means prohibit simultaneous, one-handed operation of more than one switch.

Rationale: Discussions with public transportation operators indicated that lift operator error contributes to a significant proportion of lift accidents and cause maintenance and reliability problems. Several factors contribute to lift operator error--infrequent use of the lift, different controls for different lifts, and lack of follow-up training. One means to reduce operator error is to make lift control systems functionally standard and simple. These guideline specifications seek to do this.

The first step is to have the lift operation controlled by three switches, which operate as described in Sections 2.5.2 to 2.5.4. For safety reasons the operator must have a clear view of the movement of the lift when it is in operation. This requirement means that the console for a rear door lift must be located near the rear door and be secure from unauthorized access. To assist in reducing operator error, simple instructions for the lift operator should be available.

Simultaneous, one-handed operation has been identified as a source of operator error. Proper positioning of the switches or other means can eliminate this source of driver error.

2.5.2 Power Switch

The lift controls should have a power switch with two positions--on and off. The "on" position enables lift operation and should be designated by a lighted indicator. The "off" position prevents lift movement.

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, especially since it can also act as a back-up, emergency "off" switch. The requirement for a lighted indicator is to allow the driver to discern the status of the power switch.

2.5.3 Control Function Selection Switch

2.5.3.1 The lift controls should have a function selection switch to designate the desired lift function. The switch shall have at least five designated functions (as defined) in the following order:

(1) Off - no function can be activated
(2) Deploy - lift is operated from a stowed position to a platform position
(3) Down - lowers lift platform
(4) Up - raises lift platform

(5) Stow - lift is operated from a platform position to a stowed position.

2.5.3.2 The lift may have four optional functions--outer barrier down, outer barrier up, roll stop down, and roll stop up. If any one or more of these functions are included, their order on the function switch shall be as follows:

(1) Off
(2) Deploy
(3) Down
(4) Outer Barrier Down - lowers outer barrier
(5) Outer Barrier Up - raises outer barrier
(6) Up
(7) Roll Stop Down - lower inner roll stop
(8) Roll Stop Up - raises inner roll stop
(9) Stow

2.5.3.3 The function selection switch should not allow the selection of more than one function at one time.

Rationale: The control selection switch specification identifies functions for a lift and defines these functions. Existing lifts designate functions with various terms. This specification identifies the terms that should appear on lifts produced by any manufacturer.

A distinction is made between recommended functions and optional functions. The recommended functions are considered the minimum acceptable for operation. Existing lifts have barriers or roll stops controlled either automatically or by driver action. The specification allows both options. The minimum designated functions assume roll stop automatic barrier functions.

The sequence for listing the mandatory and optional functions has been chosen to provide more standardization. The switch itself may be different (e.g., rotary, lever, or pushbutton); but the order of the functions remains the same. A lift operator can expect identical functional relationships, although the control switches may be different. Section 2.5.3.3 provides for increased safety and reliability in the lift operation by having only one function selected at a time.

The Advisory Panel also discussed having an interlock that would prevent the function selection switch from being changed when the operating switch is activated. Some members considered this option expensive and redundant with other safety features in the specifications. For these reasons such an interlock was not included.

2.5.4 Control Operating Switch

2.5.4.1 The lift controls should have an operating switch labeled "Operate" that will activate the designated function for the lift.

2.5.4.2 The operating switch should require continuous force to perform the selected function.

2.5.4.3 Release of the operating switch should stop the lift motion.

Rationale: The third type of switch on the control console is an operating switch. This switch will allow the lift to perform the designated function. For safety reasons, it is a momentary-type switch that requires continuous force for operation. If a driver is disabled or wants to stop the lift immediately, the only required action is the release of the switch. The lift operator should be able to stop and change to any control function in order to adjust to operating conditions, safety hazards, or passenger requests. The momentary nature of the operating switch in combination with the function switch provides this control capability.

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) that demonstrates these design requirements have been met should be provided.

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 such reports are:

(1) Dussault, N. B. "The Evolution and Practical Applications of Failure Modes and Effects Analyses," RADC-TR-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 a 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 bus and causing damage to the bus or the lift.

Rationale: Jacking is the support or lifting of the bus by the wheelchair lift when the platform is power driven into the ground. The release of load from the bus when the occupied platform contacts the ground is sometimes mistakenly considered jacking. Early models of some passive lifts did result in jacking and damaging to the lift or bus. To prevent such damage the control system or inherent lift design should not allow 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. It should also be possible to raise an unoccupied platform, and to stow the lift. The outer barrier and inner roll stop should be functional and controllable 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 accommodate passengers the manual system will be able to be used to take passengers off the vehicle. Also, the manual operation will allow the lift to be stowed in order for the vehicle to move. For safety reasons, the barriers and inner roll stop would be operable.

2.5.8 Interlocks and Safety Features

2.5.8.1 Interlocks should prevent vehicle movement unless the lift is stowed.

2.5.8.2 Interlocks should 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 unless the inner roll stop and outer barrier are raised and operational.

2.5.8.5 An interlock or inherent design feature should not allow the outer barrier to be lowered unless the lift platform is at an unloading surface below the vehicle floor level.

Rationale: The interlocks and safety features are designed to prevent unsafe conditions. The first interlock guideline prevents vehicle movement when a passenger is on a lift or when the lift extends beyond the normal width of the vehicle. 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.

One safety hazard identified with lift operations is going into a stow position when a lift is occupied. The control system or the inherent design of the lift would prevent this condition.

Barrier or roll stop failure can create a hazardous condition. To prevent this condition the lift should not be able to operate up or down unless the inner roll stop and outer barrier are up and working properly.

Similarly, the lift operator cannot inadvertently lower the outer barrier unless the platform is at an unloading surface. This feature means the platform would have to be at ground level or on a surface that allows safe boarding and a lighting.

2.5.9 Maintenance Controls (Optional)

The lift should have a separate maintenance control that allows complete lift operation, is inaccessible during normal vehicle operation, and is located in a functional position for maintenance of the lift. The design of the maintenance controls should ensure all safety features of lift operations when the maintenance controls are not in use.

Rationale: The control requirements for normal operation and maintenance are different depending on console location and maintenance access. To assist in the maintenance of the lift, it is suggested that separate maintenance controls be provided. However, this requirement is optional. An operator will have to decide whether the initial cost for such controls will be offset by reduced maintenance costs.

2.5.10 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: The 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.

2.5.11 Lift Operational Requirements

2.5.11.1 The maximum speed of platform motion should be 6 inches per second. The operating time required to fully cycle the lift (deploy, down, up, and slow with barrier operation) should not exceed 45 seconds at 20 F and not exceed 65 seconds at -10 F.

2.5.11.2 The maximum platform horizontal and vertical acceleration shall be 0.2g.

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 considered fast by the Advisory Panel. The transit authority bid packages reviewed have specified speeds and velocities in a wide variety of ways. The speeds and operating times specified here are designed to be compatible with existing condition, acceptable to the wheelchair occupant, and should not place new design requirements on the lift manufacturer.

"Safety Guidelines for Wheelchair Lifts on Public Transit Vehicles" states that vertical and horizontal acceleration rates shall not exceed 0.3g. The specified value of acceleration permitted in this section is lower and provides more desirable conditions for the lift user with very little increase in operating cycle time.

The above referenced report also recommends that the rate for jerk, the rate of change of acceleration, not exceed 0.3g/second throughout the horizontal motion of the occupied lift platform. The Advisory Panel discussed the rate of jerk. However, little data could be identified that would guide the establishment of a rate for jerk. Both 0.2g/second and 0.3g/second were discussed. Given the lack of data, the Advisory Panel made no recommendation in this area.

3.0 TESTING, CERTIFICATION, AND INSPECTION

3.1 Design Tests

The tests defined in Section 3.1 shall be performed on a 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 vehicle installation and when supplied by electric, hydraulic, air, or other power source of output equal to that normally available on the vehicle. Only one representative production unit is required to be tested for certification for design tests 3.1.1 through 3.1.7. Design tests 3.1.1 through 3.1.5 should be conducted on the same unit, without failure, in the order given, and without any repairs or maintenance other than that permitted by Section 3.1.11. The contractor may elect to conduct the tests specified in Section 3.1.6 with the lift installed in a vehicle. Design tests 3.1.8 and 3.1.9 require a lift model and vehicle model combination. For certification these tests need only be conducted once for each lift and vehicle model combination.

3.1.1 Durability Tests

3.1.1.1 Vertical Cycling Test. 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 or 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 0.2g.

3.1.1.2 Deployment Cycling Test. The lift platform should be deployed and stowed 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 requirements or both tests.

Rationale: The tests in Section 3.1.1.1 and 3.1.1.2 are adapted from those required by the California Administrative Code. 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 cycles of deploying, lowering, raising, and stowing and through 10 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 exposure temperatures.

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 increase the test weight to the 600 pound limit contained in these specifications, explicitly to require the lift to meet all performance requirements at the test temperature, and to change the cycling to avoid loading and unloading the lift during the test.

3.1.3 Platform Deflection Test

A static load of 600 pounds should be applied through the centroid of a test pallet 24 inches by 24 inches 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 between the loaded position and its unloaded position.

Rationale: The California Administrative Code has a platform deflection requirement. For the guideline specifications platform deflection has been defined in terms of test requirements. The test requirement have been developed based on the design load and the platform deflection requirement in the California Administrative Code.

3.1.4 Self-Damage Tests

The controls should be held in operating position for five (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 deploy, stow, 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 is adapted from the California Administrative Code. It allows 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 Barrier and Roll Stop Tests

3.1.6.1 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 Explorer Modular Power Chair, 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 an 8 degree outward slope
(f) the lift platform in a raised position.

The Everest and Jennings 3M Marathon or the Invacare Power Rolls Arrow Model should be equipped with a standard adult size seat, standard foot rests, 20-inch rear wheels, eight-inch front castors, 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 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.

Rationale: As discussed in the rationale for Section 2.2.6, existing barriers have failed in tests using powered wheelchairs. This test of the outer barrier is designed to ensure that barriers do not fail under the test conditions and that a wheelchair and secured occupant could remain on the platform.

The four models represent two types of current wheelchairs that are powered and could override barriers. They have been selected because they have been identified as representing those wheelchair 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 designed 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 maximum 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.

The test in Section 3.1.6.1 is recommended as an interim test by the Advisory Panel. The Advisory Panel also recommends that more precise test requirements be developed that identify specific forces, angles, and other factors to be tested. These requirements would simulate conditions described in Section 3.1.6.1 and provide a more definitive test procedure and guideline.

The 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 three 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 2.2.1.3).

3.1.7 Static Load 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 fractures have occurred.

Rationale: The test given in Section 3.1.7 is adapted from the California Administrative Code. Section 3.1.7 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 conducted on a lift installed in an actual vehicle of the same model as 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.

3.1.9 Interlock Safety Tests

The Contractor should submit a test plan for approval by the Procuring Agency or certification of tests that demonstrate that the lift model, when installed in the vehicle model, meets the safety related interlocks as given in Section 2.5.8.

Rationale: This test will demonstrate the level of safety provided by the lift interlocks.

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. The visual inspection is a means to determine if the tests have been passed.

3.1.11 Maintenance During Tests

During the Durability Tests of Section 3.1.1, the inspection, lubrication, maintenance, and replacement of parts (other than 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 taken 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 during the tests, the test would have to be repeated.

3.1.12 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 Tests (Optional)

The contractor should submit for approval to the Procuring Agency a test 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. The Procuring Agency may witness any or all of these acceptance tests. A mutually agreed upon notification time prior to the conduct of a test should be made between the two parties. The test results should be recorded, witnessed, and submitted to the Procuring Agency as proof of meeting the acceptance criteria of the approved test plan.

Rationale: This section is optional since most lifts would be purchased as a part of a vehicle procurement and any lift acceptance testing would be included in the vehicle acceptance testing. Acceptance testing needs to be considered as a separate price item in the lift procurement. The more comprehensive the acceptance tests, the more expensive this option can be to the Procuring Agency. The successful completion of acceptance tests is the time at which the warranty period normally begins.

3.3 Environmental Tests

The contractor should provide the Procuring Agency with (1) certified documentation to lift performance in revenue service in transit environments similar to those that will be encountered or (2) certified documentation of tests that demonstrate that the lift should function reliably in the transit operating environment.

Rationale: Tests described in Sections 3.1 and 3.2 are conducted in laboratory or test conditions that do not attempt to simulate a revenue service, transit environment. The Advisory Panel concluded that a lift should not be put into regular revenue service until it has been tested to determine the effects of dirt, water, salt, ice, road conditions, and other in-service environmental factors on reliability and service life.

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.)