Memorandum

MIAMI-DADE COUNTY

Date: September 12, 2007

TC
Agenda Item No. 8(F)

To: Honorable Chairman Dorrin D. Rolle
and Members, Transit Committee

From: George M. Burgess
County Manager

Subject: Findings of Feasibility Study for the Installation of Cylindrical Posts Between Bus Passenger Benches or Shelters and the Edge of the Road at Bus Stops in Unincorporated Miami-Dade County

BACKGROUND

This report is presented in response to Resolution No. R-282-07 adopted by the Board on March 6, 2007 and sponsored by Commissioners Rolle and Edmonson requesting that a study be conducted to examine the feasibility of installing cylindrical posts between bus passenger benches or shelters and the edge of the road at Miami-Dade Transit (MDT) bus stops in Unincorporated Miami-Dade County. MDT solicited the services of a traffic consultant, F.R. Aleman & Associates, to study the feasibility of installing cylindrical posts, commonly known as bollards, between bus passenger benches or shelters and the edge of the road. The purpose of these bollards would be to act as a barrier and protect the patrons from errant vehicles that leave the roadway.

OBJECTIVE

Investigate and document the potential benefits, risks, regulatory issues, time and cost of installing cylindrical posts for passenger safety at over 2,300 bus stops throughout Miami-Dade County. The 2,300 bus stops consist of 1,100 bus shelters and 1,200 bus benches.

The study includes the investigation of 300 bus stop locations representing the various typical conditions that exist at bus stop with benches or shelters, and discusses the benefits, risks, costs, time frame for implementation, and compliance requirements for the installation of these bollards.

EXECUTIVE SUMMARY

Findings from the study indicate most of the benches and shelters do not have the allowable space required for bollards to be installed and meet Federal, State and County design standards. Bus routes generally travel along the County's busiest roadways. In most cases these streets have been widened to accommodate the increase in traffic over the years. As a result, our busiest streets generally have very limited right-of-way left. In nearly all cases it would not be possible to install bollards in front of bus benches and shelters without violating the standards set in the Florida Manual of Uniform Minimum Standards for Design, Construction and Maintenance of Streets and Highways, more commonly referred to as the Florida Green Book.

The Florida Green Book requires that structures in the public right-of-way along roads be set back a minimum of four (4) feet where there is curb and gutter and a minimum of fourteen (14) feet where there is no curb and gutter. The distance increases with the design speed of

the road. The purpose of this requirement is to provide a "clear recovery zone". The clear recovery zone provides motorists that have temporarily lost control of their vehicle a clear area without impediments allowing them to regain control of their vehicle and return to the roadway without danger of injury to themselves and their passengers. Shelters and bus benches are generally located at the limit of the clear zone. If bollards are place in front of the shelters or bus benches, they would most likely be in violation of the roadside clear zone and present a life threatening hazard to motorists.

Additionally, the Florida Green book requires that roadway intersections have an unobstructed view of the traffic in the intersection. This is called the site distance triangle. Most bus stops with shelters or benches have been placed just beyond the limits of the site distance triangle to accommodate the shelter or bus bench. Bollards placed in front of the shelters or benches would fall within the site distance triangle and would be in violation of State and County regulations and present a life threatening hazard to motorist.

Additional significant findings from this report are provided for your information below as follows:

- Bollards are designed for low speed impacts. A high speed collision at bus stop benches or shelters with bollards could result in pedestrians being hit or trapped by a bollard driven out of the ground.

- Designs for most locations would require bollards to be installed within four (4) feet of the curb and gutter, or fourteen (14) feet from flush roadways, violating Clear Zone guidelines.

- Objects installed within the Clear Zone are designed to bend or break upon impact. The Bollard would not bend or break.

- Maintaining 36 inches of clear width for disabled persons restricts bollards from being installed on most sidewalks.

- Bollards can obstruct the driver's view of traffic at an intersection.

- Large foundations and conflicts with subsurface utilities make designs impractical to implement and most locations.

- Shelter layouts with sufficient distance from the roadway are possible locations where bollards can be installed without violating State or County regulations. Based on the inventory, 11% of bus shelters (121 bus shelters) throughout the county are possible candidates for bollard retrofits. Benches are not recommended.

- The average cost for installation is $22,000. The cost of installation at 121 locations is approximately $2,662,000. Design costs are an average of 5% of construction, for a cost of $133,100. Total cost for installation is approximately $2,795,100.

- Design, Permitting and Construction would take approximately 12 months. The County's solicitation of a design consultant and contractor would take approximately 20 months for a total of thirty two (32) months.

The benefits of typical bollards for protection are limited. A typical bollard, like those found in parking lots or adjacent to fire hydrants, cannot withstand the impact associated with errant vehicles leaving the roadway. In fact, a bollard specifically designed to withstanding high speed collisions may actually increase the risk of a deadly incident as the driver or passenger of the errant vehicle are most likely to suffer serious injury.

While the concept of using bollards to protect the patrons of our bus system would at first blush appear to increase public safety, research indicates that it would in all likelihood result in the opposite effect. Therefore, cylindrical posts are not recommended for protection of pedestrians at bus stops against errant vehicles that leave the roadway. However, MDT will continue to explore other cost-effective measures achieving this purpose that may be in use by other transit systems.

Assistant County Manager

MEMORANDUM

Agenda Item No. 11(A)(21)

TO:	Honorable Chairman Bruno A. Barreiro and Members, Board of County Commissioners	**DATE:**	March 6, 2007
FROM:	Murray A. Greenberg County Attorney	**SUBJECT:**	Resolution directing County Manager to examine feasibility of installing cylindrical posts between bus benches or shelters and edge of the road

The accompanying resolution was prepared and placed on the agenda at the request of Commissioner Dorrin D. Rolle and Commissioner Audrey M. Edmonson.

for (Murray A. Greenberg)
County Attorney

MAG/jls

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MEMORANDUM

(Revised)

TO: Honorable Chairman Bruno A. Barreiro and Members, Board of County Commissioners

DATE: March 6, 2007

FROM: Murray A. Greenberg County Attorney

SUBJECT: Agenda Item No. 11(A)(21)

Please note any items checked.

_____ **"4-Day Rule" ("3-Day Rule" for committees) applicable if raised**

_____ **6 weeks required between first reading and public hearing**

_____ **4 weeks notification to municipal officials required prior to public hearing**

_____ **Decreases revenues or increases expenditures without balancing budget**

_____ **Budget required**

_____ **Statement of fiscal impact required**

_____ **Bid waiver requiring County Manager's written recommendation**

_____ **Ordinance creating a new board requires detailed County Manager's report for public hearing**

_____ **Housekeeping item (no policy decision required)**

_____ **No committee review**

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Approved _____ Mayor
Veto _____
Override _____

Agenda Item No. 11(A)(21)
3-6-07

RESOLUTION NO. _____

RESOLUTION DIRECTING THE COUNTY MANAGER TO EXAMINE THE FEASIBILITY OF INSTALLING CYLINDRICAL POSTS BETWEEN BUS PASSENGER BENCHES OR SHELTERS AND THE EDGE OF THE ROAD AT MIAMI-DADE TRANSIT BUS STOPS IN UNINCORPORATED MIAMI-DADE COUNTY

WHEREAS, there have been numerous accidents involving transit patrons waiting at Miami-Dade County bus stops; and

WHEREAS, the placement of cylindrical posts between bus passenger benches or shelters and the edge of the road may serve to prevent accidents and thus save lives,

NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF COUNTY COMMISSIONERS OF MIAMI-DADE COUNTY, FLORIDA, that this Board hereby directs the County Manager to prepare a report to determine the feasibility of installing cylindrical posts between bus passenger benches or shelters and the edge of the road. This report shall be presented to the Transit Committee within 60 days of the effective date of this Resolution and will include: total estimated cost, a time schedule for possible implementation, engineering or planning concerns, implications with the ADA, and potential safety benefits and risks.

The foregoing resolution was sponsored by Commissioner Rolle and Commissioner Audrey M. Edmonson and offered by Commissioner , who moved its adoption. The motion was seconded by Commissioner and upon being put to a vote, the vote was as follows:

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Bruno A. Barreiro, Chairman
Barbara J. Jordan, Vice-Chairwoman

Jose "Pepe" Diaz
Carlos A. Gimenez
Joe A. Martinez
Dorrin D. Rolle
Katy Sorenson
Sen. Javier D. Souto
Audrey M. Edmonson
Sally A. Heyman
Dennis C. Moss
Natacha Seijas
Rebeca Sosa

The Chairperson thereupon declared the resolution duly passed and adopted this 6th day of March, 2007. This resolution shall become effective ten (10) days after the date of its adoption unless vetoed by the Mayor, and if vetoed, shall become effective only upon an override by this Board.

MIAMI-DADE COUNTY, FLORIDA
BY ITS BOARD OF
COUNTY COMMISSIONERS

HARVEY RUVIN, CLERK

By:_____
Deputy Clerk

Approved by County Attorney as
to form and legal sufficiency.

Bruce Libhaber

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BUS BENCH AND SHELTER CYLINDRICAL POST PROTECTION

FEASIBILITY STUDY

Prepared for:

MIAMI-DADE COUNTY

Delivering Excellence Every Day

Prepared by:

F.R. ALEMAN & Associates, Inc.
CONSULTING ENGINEERS & SURVEYORS

August 31, 2007

EXECUTIVE SUMMARY

This report investigates the feasibility of installing cylindrical posts between bus passenger benches and shelters and the edge of the road at Miami-Dade Transit (MDT) bus stops throughout Miami-Dade County. Findings from the study indicate most of the benches and shelters do not have the allowable space required for bollards to be installed and meet Federal, State and County design standards. The benefits of typical bollards for protection are limited. A typical bollard, like those found in parking lots or adjacent to fire hydrants, cannot withstand the impact associated with errant vehicles leaving the roadway. A bollard specifically designed to withstanding high speed collisions actually increase the risk of a deadly incident as the driver or passenger of the errant vehicle are most likely to suffer serious injury. Therefore, cylindrical posts are not recommended for protection of pedestrians at bus stops against errant vehicles that leave the roadway.

Significant findings from this report are as follows:

- Bollards are designed for low speed impacts or for security applications.
- A high speed collision at bus stop benches or shelters with bollards could result in pedestrians being hit or trapped by one driven out of the ground. The installation of Bollards could create a more dangerous situation for both pedestrians and drivers
- At the majority of locations installation of bollards would violate design standards and codes for Clear Zone, Sight Distance and the Americans with Disabilities Act.
- Objects installed within the Clear Zone are designed to bend or break upon impact.
- Maintaining 36 inches of clear width for disabled persons restricts bollards from being installed on most sidewalks.
- Bollards can obstruct the driver's view of traffic at an intersection.
- Large foundations and conflicts with subsurface utilities make designs impractical to implement at most locations.
- Shelter layouts with sufficient distance from the roadway are possible locations where bollards can be installed without violating State or County regulations. The safety benefits of installing bollards at these locations would most likely be limited.
- Based on the inventory, 11% of bus shelters throughout the county are possible candidates for bollard retrofits, and at benches they are not recommended.
- There are approximately 1100 bus shelter locations, construction costs for 121 shelter sites are estimated at $2,662,000.

- Design, Permitting and Construction will take approximately twelve (12) months.

LIST OF FIGURES AND TABLES

1. INTRODUCTION

F.R. Aleman and Associates, Inc. was retained by Miami Dade Transit to investigate the feasibility of installing cylindrical posts between bus passenger benches and shelters and the edge of roadways throughout locations in Miami-Dade County. The study was sanctioned by the Commissioners of Miami-Dade County to improve safety at these locations and provide protection from vehicle impacts. The purpose of this report is to investigate and document the potential benefits and risks of installing cylindrical posts for passenger safety at over 2,300 bus stop benches and shelters throughout Miami-Dade County.

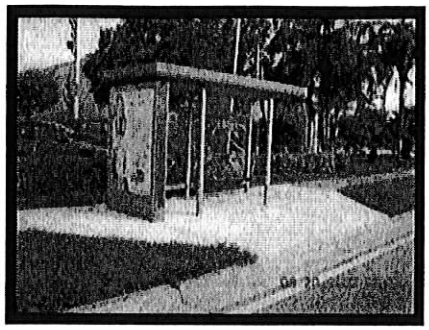
2. STUDY METHODOLOGY

The study was undertaken in accordance with the Letter of Authorization issued by Miami Dade Transit (MDT) dated June 2007. The study methodology was developed to address questions and concerns in the scope of services set forth by the Commissioners of Miami-Dade County to conduct a feasibility study for proposed safety improvements at bus stop locations countywide. The study includes an inventory of 300 locations representing the various conditions that exist at bus stops with benches or shelters, and discusses the benefits, risks, cost, timeline of implementation, and compliance requirements for the installation of cylindrical posts.

3. PROPOSED SAFETY IMPROVEMENTS

Upon direction of the Commissioners of Miami-Dade County, F.R. Aleman & Associates was selected by Miami-Dade Transit to study the feasibility of installing cylindrical posts, commonly known as bollards, between bus passenger benches or shelters and the edge of the road. The purpose of these bollards would be act as a barrier or protect the patron from errant vehicles that leave the roadway. Ideally, the bollard would absorb the impact from the collision and stop, or deflect, the vehicle from pedestrians waiting at the bus stop.

The bollards must be designed to improve safety without endangering drivers and pedestrians. They would have to be placed in front, and on the sides, to protect against vehicles approaching in both directions parallel to the bus stop. A typical design would have bollards spaced just a few feet from each other, and capable of stopping errant vehicles moving at the roadway's design speed. They must also comply with American with Disabilities Act (ADA) Standards for Accessible Design, Florida Department of Transportation (FDOT) Design Standards and be approved by Miami-Dade Public Works Department.



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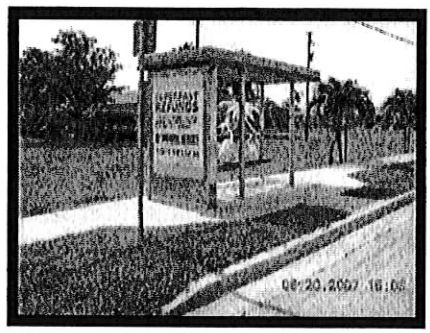

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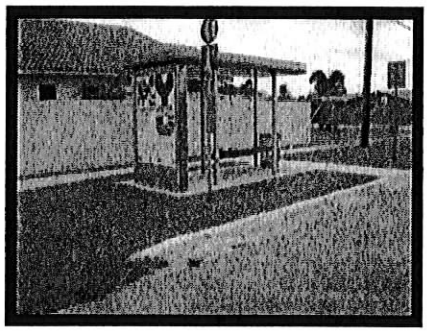

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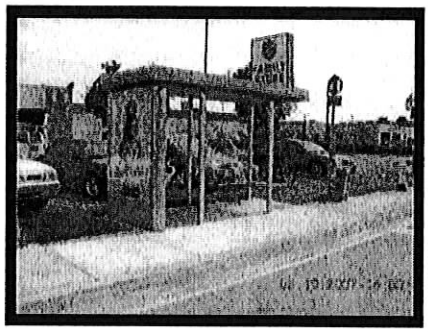

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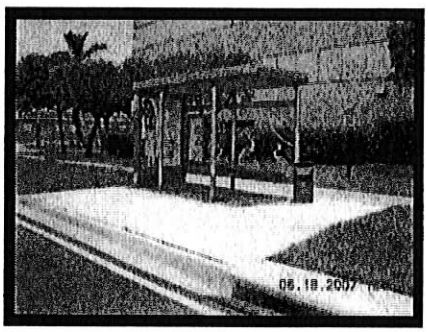

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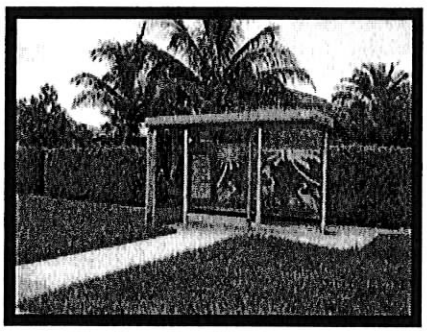

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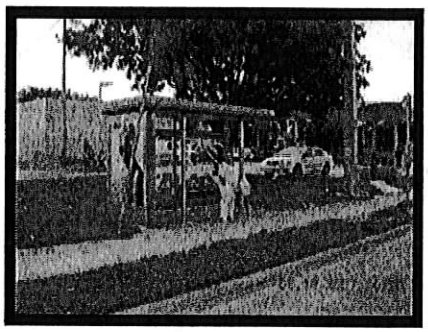

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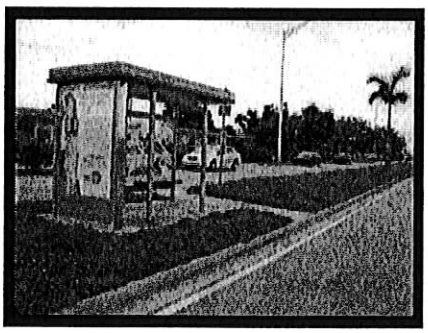

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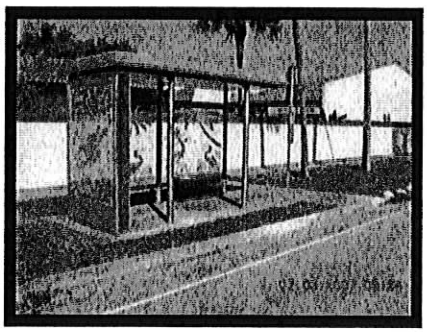

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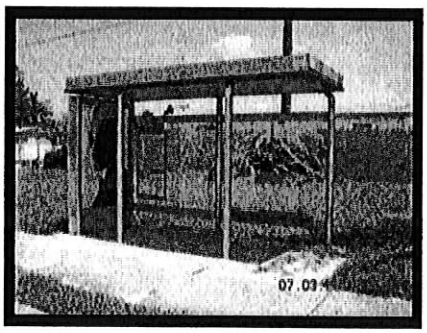


Bus Stop No: MD6-0732.0000

R. ALEMAN & Associates, Inc. CONSULTING ENGINEERS

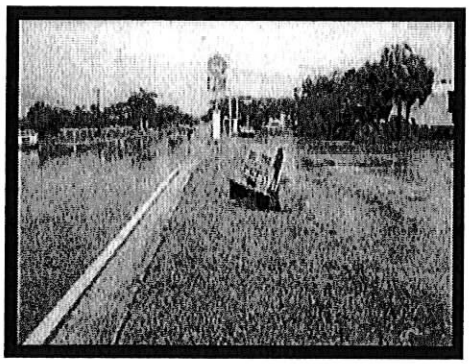
Bus Shelter Photos
Miami-Dade County

FIGURE 1

Bus Stop No: MD1-0033.0000

Bus Stop No: MD1-0263.0000

Bus Stop No: MD2-0559.0200



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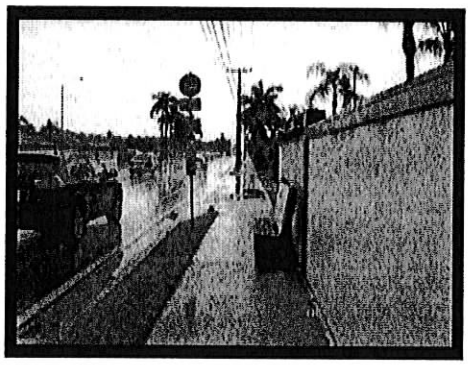

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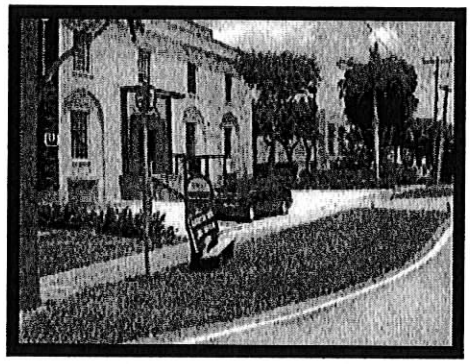

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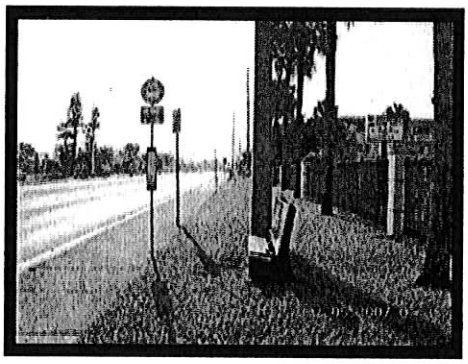

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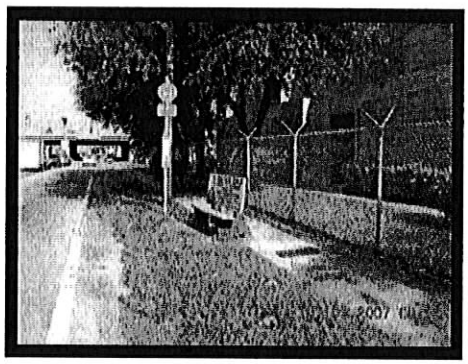

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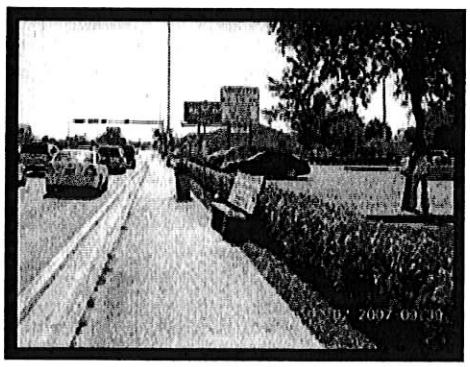

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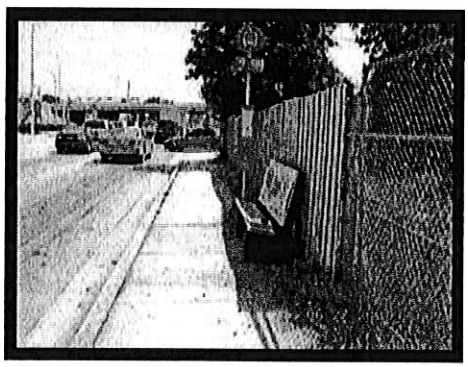

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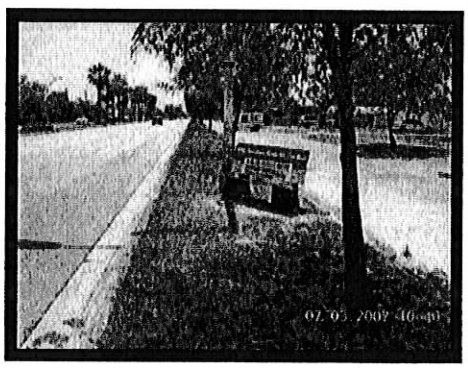


Bus Stop No: MD6-0726.0000

R. ALEMAN
& Associates, Inc.
CONSULTING ENGINEERS

Bus Bench Photos
Miami-Dade County

FIGURE 2

4. EXISTING BUS BENCH & SHELTER LAYOUTS

The placement of benches and shelters can vary depending on the location and available Right-of-Way, but typically they are set on the back of sidewalk or behind it if space is available. The Right-of-Way is an easement, or strip of land, that is designated for transportation facilities such as rail lines, highways and roads. As the roadway expands, less space is available for installing curbside features such as benches, shelters, signs and utility poles. Figure 1 and Figure 2 show photos of various benches and shelters in Miami-Dade County.

The shelters are typically fourteen (14) feet by six (6) feet and sit on a reinforced concrete slab that is accessible to a sidewalk if present. Figures 3, 4 and 5 shows various shelter layouts along roadways and Transit Facilities Guidelines for Curbside Bus Shelters can be found in the Appendix. They provide protection from the elements and promote the use of public transportation. The bus shelters are designed to accommodate disabled persons and meet the American with Disabilities Act requirements. The shelters provide adequate mobility for wheelchair or mobility aid users by providing clear floor space within the shelter, maintaining clear width and access to sidewalks.

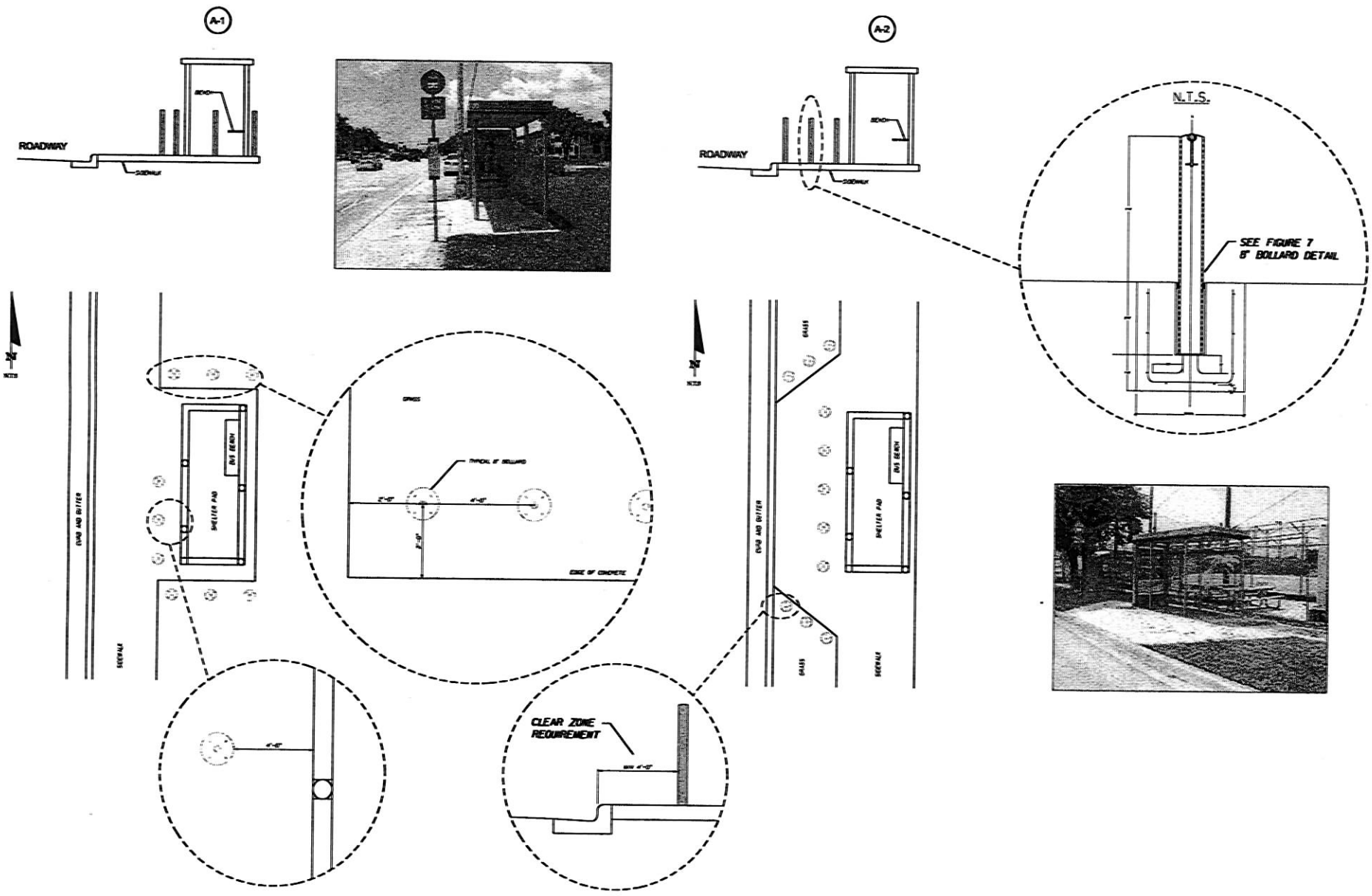
Benches are a low cost option for provide a waiting area for commuters. Often these are placed where Right-of-Way is limited and shelters are not a viable option. They are also seen at bus stops that experience a low volume of commuters throughout the day. Typically they are six (6) feet by two (2) feet, and constructed of concrete and/or wood. Figure 6 shows various placements of benches at roadways with different cross sections. Placement can vary, but typically they set on the back of sidewalk or behind it if space if available. Some of the benches found on major arterials are currently in violation of clear zone requirements. The table below summarizes the inventory layout types that were analyzed.

Bus Bench and Shelter Layouts

TYPE A	TYPE B	TYPE C	TYPE D
94	85	12	109

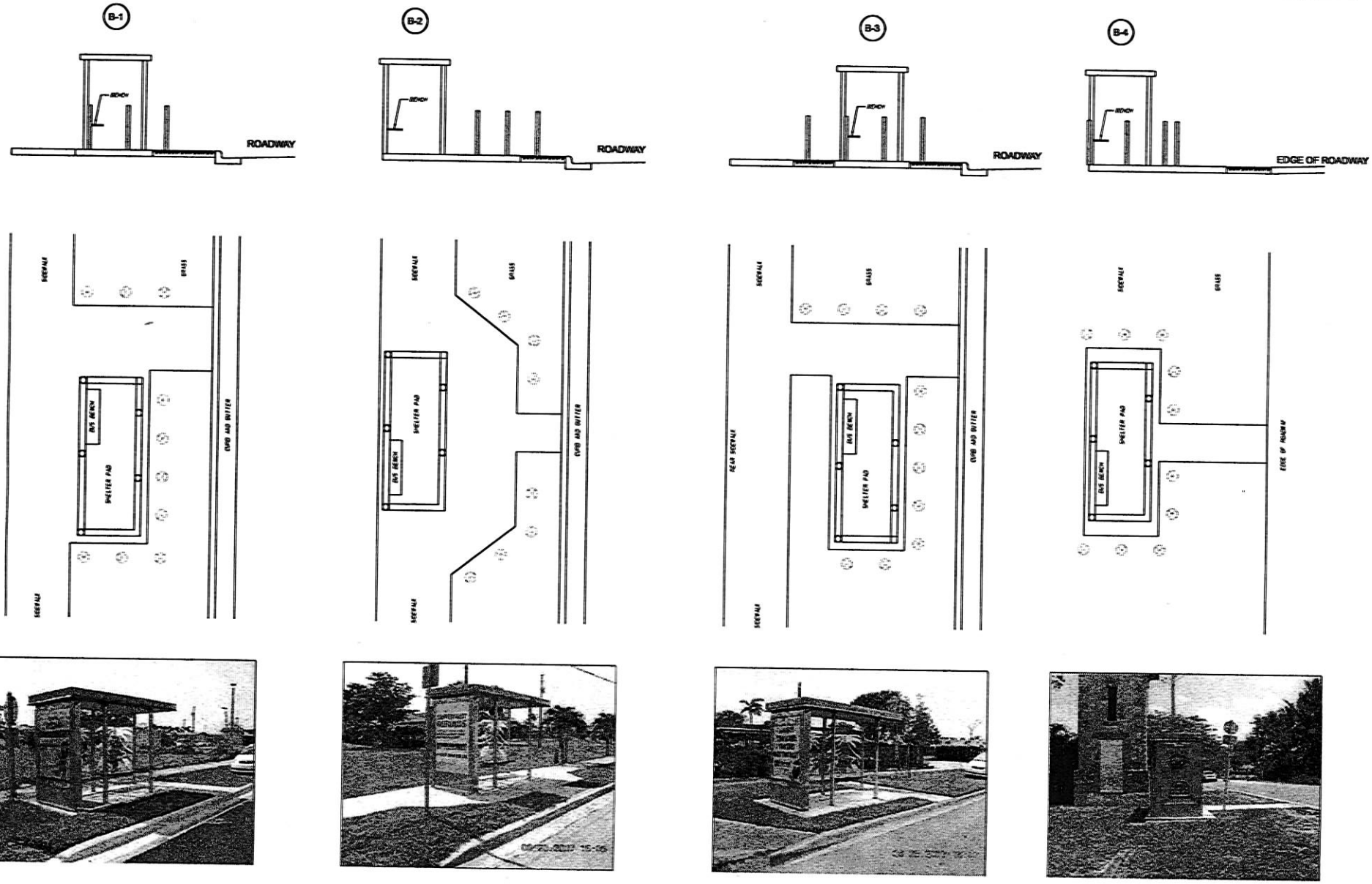
5. SAFETY BENEFITS

The safety benefits of typical bollards are quite limited. The typical bollard is designed to protect against low speed impacts such as vehicles slowing to make turns and navigation at parking stalls. The errant vehicle could be deflected or stopped by one of the bollards if a collision occurs. Bus stops which are located in parking lots would be the likely candidate for a bollard retrofit.



BUS SHELTER LAYOUT - TYPE A

FIGURE 3



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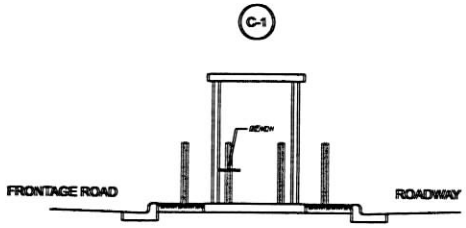
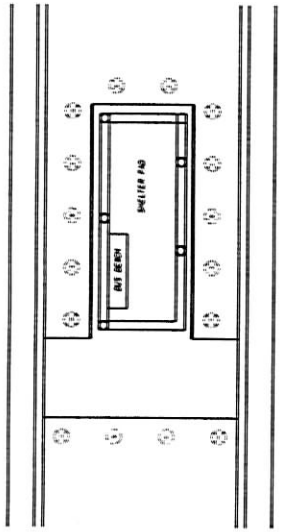
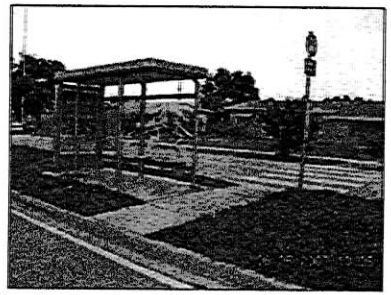
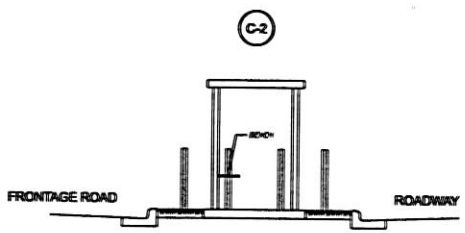
BUS SHELTER LAYOUT - TYPE B

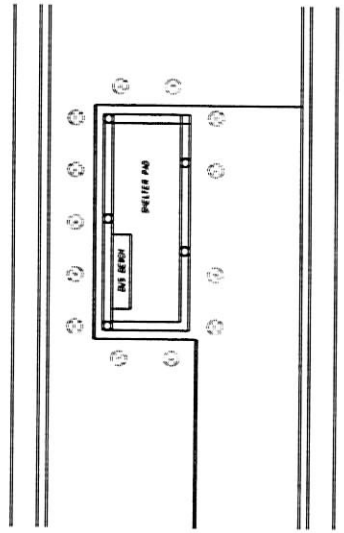
FIGURE 4

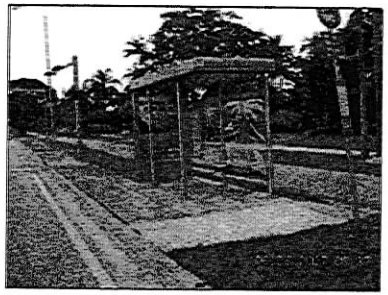


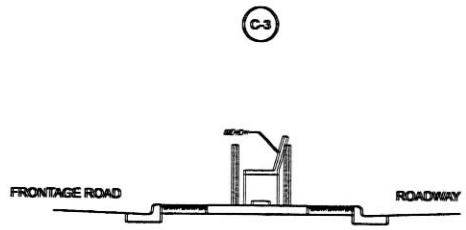


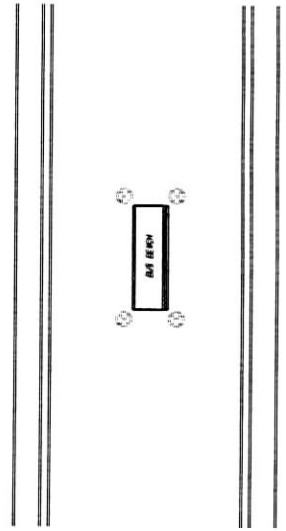


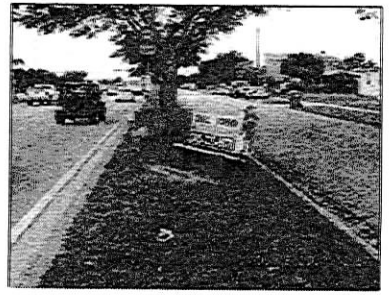








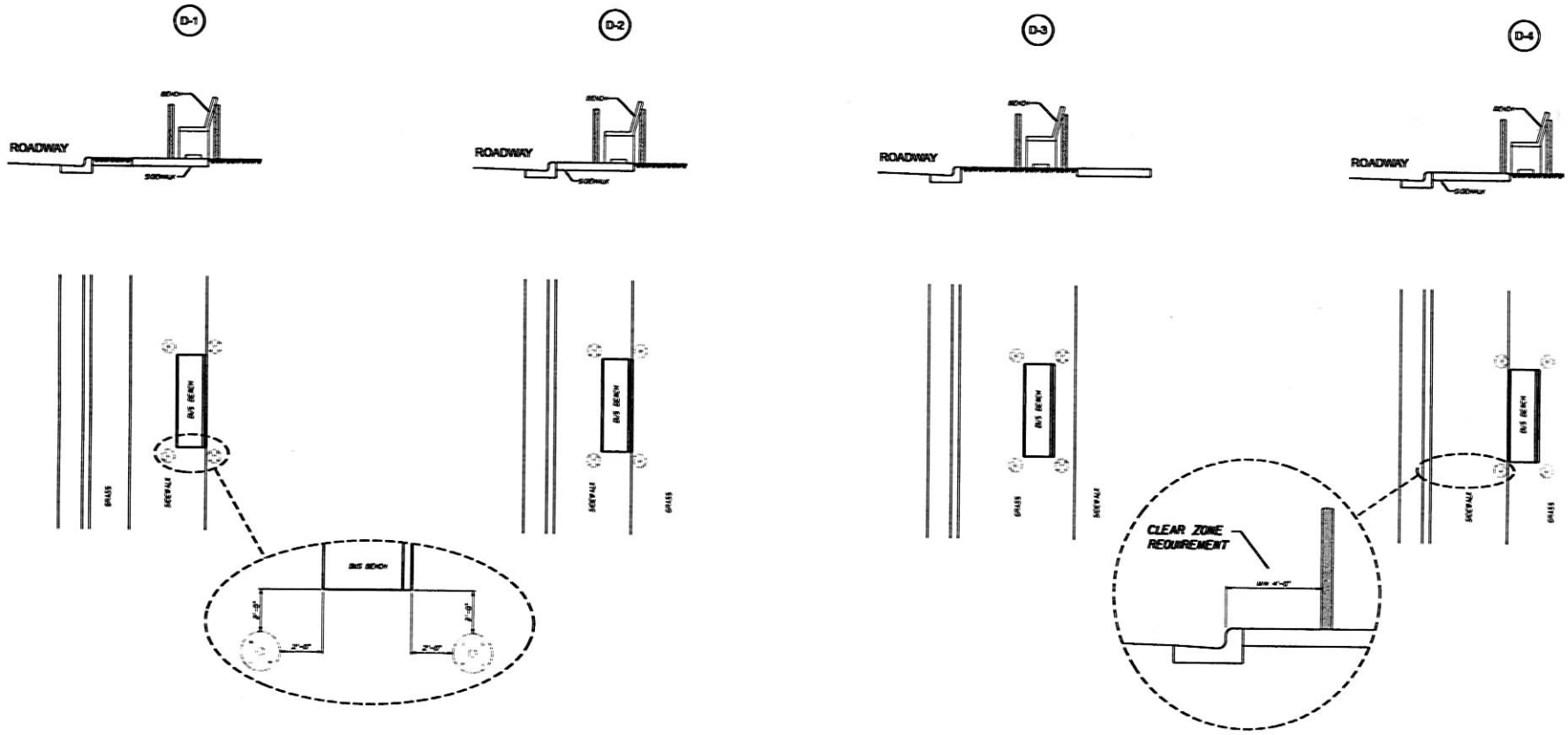


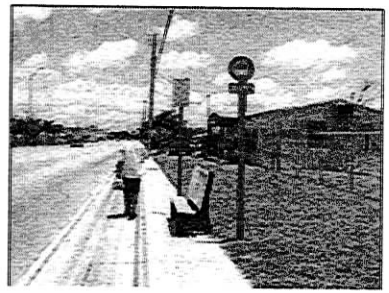


18

BUS SHELTER LAYOUT - TYPE C

FIGURE 5





BUS BENCH LAYOUT - TYPE D

FIGURE 6

6. SAFETY RISKS

Typically bollards are used as a low speed deterrent, and not high impact collisions. Security bollards are designed for high speed collisions, but are larger and create more of a hazard for drivers and pedestrians. The low speed bollards are placed to alert drivers of objects in close proximity to the roadway and provided minimal deflection. They also aid in channeling traffic and alerting truck drivers of possible turn radius conflicts. Bollards that have experienced collisions at high impacts are known to be bent, or at worst, driven out of the ground. They pose an added threat to pedestrians if they are close to one being struck. A collision at bus stop benches or shelters with bollards could result in a pedestrian being hit or trapped by one driven out of the ground.

The installation of bollards at bus shelters presents safety hazards for drivers and pedestrians. Protection at bus stops with limited Right-of-Way would require installation within the Clear Zone and increase collisions with vehicles. This notion would contradict the concept of providing a safe roadway for drivers by introducing hundreds of potentially dangerous road hazards throughout the county.

A typical design for protection of a bus stop would require multiple bollards spaced a few feet apart, and would have to be placed four (4) feet from the curb and gutter to satisfy Clear Zone requirements. The Clear Zone provides motorists that have temporarily lost control of their vehicle a clear area without obstructions allowing them to regain control of their vehicle and return to the roadway. Most objects that are within the clear zone are designed to bend or break when impacted by a vehicle limiting the danger to an errant vehicle. Sections where the roadway curb and gutter is not present require a minimum of fourteen (14) feet to satisfy this requirement.

The Florida Green book requires that roadway intersections have an unobstructed view of the traffic in the intersection. This is called the site distance triangle. The bollards would have to be located so they would not compromise the visibility of motorists entering the roadway from other roads or driveways. Most bus stops with shelters or benches have been placed just beyond the limits of the site distance triangle. Bollards placed in front of the shelter or benches would fall within the site distance triangle and would be in violation of State and County regulations, creating a conflict for drivers at specific approaches. See Appendix for departure sight triangles for vehicle approaches. Drivers approaching northbound at an intersection may have difficulty seeing incoming traffic on the eastbound and westbound approaches. Bollards viewed at an angle could appear to the driver as a wall and obstruct the view of drivers.

Benches are typically installed at bus stops where, due to limited Right-of-Way, a shelter cannot be accommodated. The bus bench is placed at the back of sidewalk which generally is the limit of the Right-of-Way typically less than eight (8) feet from the edge or roadway. Under this scenario if bollards are placed in front of the bench, the bollards would violate both the Clear Zone and the American with Disability Act (ADA) requirements

Installing bollards at these locations would violate the clear width requirements for persons using wheelchair or mobility aids. The minimum clear width of an accessible route is 36 inches according to the Department of Justice ADA Standards of Accessible Design. Installing bollards that create minimal maneuvering capabilities increases the potential danger for disabled persons. Some may be forced to conduct dangerous maneuvers to clear the bollards at high volume roadways.

7. BOLLARD TYPES

Bollards can be used to protect roadside objects such as parking meters or fire hydrants, channel vehicles, and limit vehicle access. They are designed for low speed impacts. A typical bollard is shown in Figure 7. This 8" bollard has been designed for an impact force of 9,000 pounds applied at the top of the bollard. It requires a foundation which is three (3) feet in diameter and depth. Roadways with higher speed limits would require bollards with larger foundations making it difficult to install. Conflicts with subsurface utilities will create feasibility concerns during design and construction. Relocating multiple utilities lines at any given site will increase the costs and timeline of installation.

Security bollards are designed for intentional high speed impacts. They can stop a truck at high speeds, and are used at power plants, embassies, courthouses, and other government buildings. The Department of State (DOS) Bureau Diplomatic Security has developed certifications based on their crash-testing procedures, the details of which can be found in the Appendix. The highest classification (K12) specifies that the barrier can withstand the impact of a 15,000 lb vehicle running at 50 mph. This type of protection is costly and requires large foundations which are not practical.

8. INSTALLATION FEASIBILITY

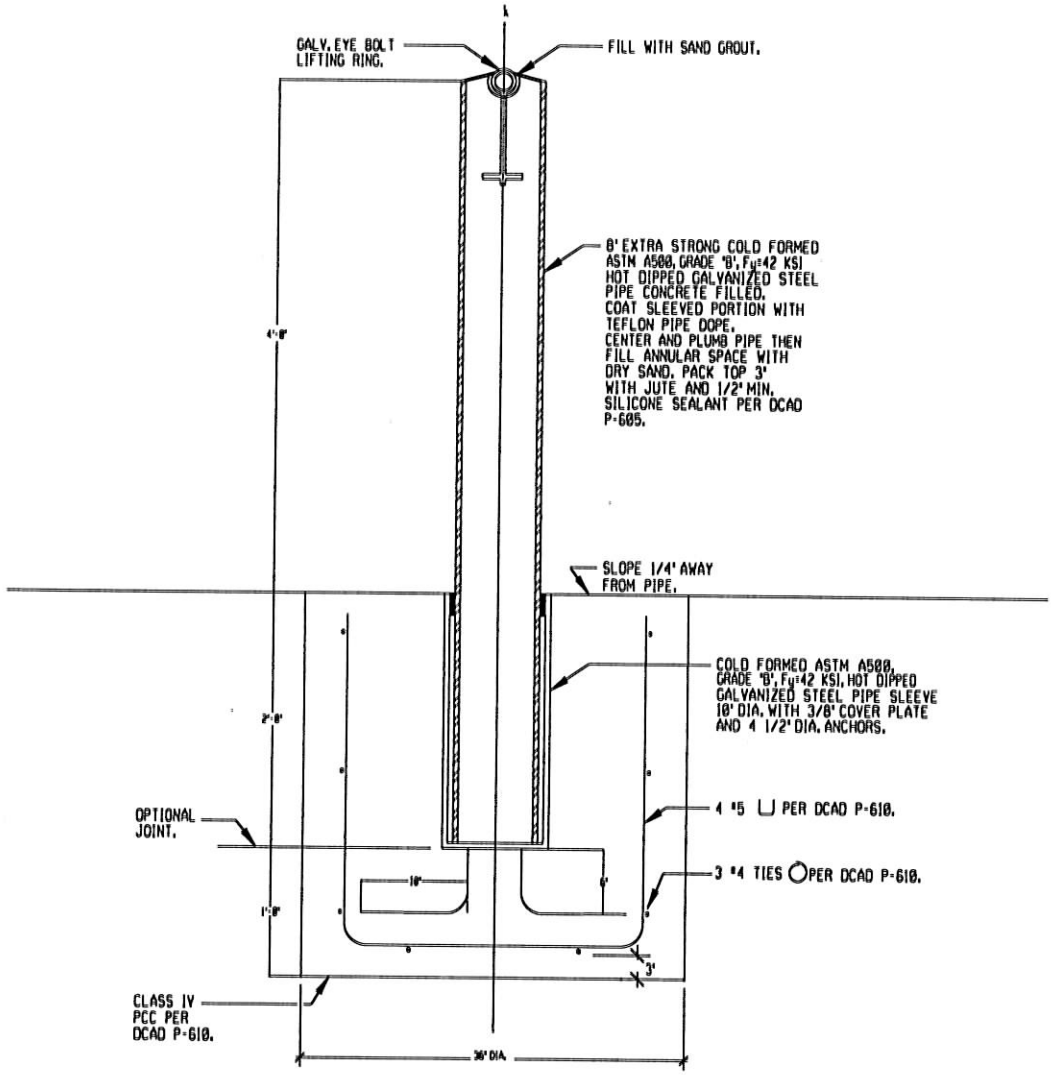
The bollards must be designed to improve safety without endangering drivers and pedestrians. They would have to be placed in front, and on the sides, to protect against vehicles approaching from both directions parallel to the bus stop. Locations where a frontage road for driveway access is behind the shelter or bench, bollards must be considered. A typical design would have bollards spaced just a few feet from each other, and capable of stopping errant vehicles moving at the roadway's design speed. They must also comply with the American with Disabilities Act (ADA) Standards for Accessible Design, as well as, Florida Department of Transportation (FDOT) Design Standards.

Based on the inventory, the majority of bus stops with benches are poor candidates for the installation of bollards as a safety measure. They are typically used at locations with limited space and, at a minimum, a five (5) foot sidewalk separating the curb from the Right-of-Way. Violations of the ADA requirements and Clear Zone widths set forth by the Florida Department of Transportation Design Standards restrict the feasibility of installing bollards at these locations.

Shelters must meet the same space requirements as benches and would require more bollards, which are impractical due to the size of the foundations. Shelter layouts such as Type B-4 in Figure 4 are a candidate for bollard retrofits. Provided the shelter is offset far enough from the roadway and sidewalks are not present, these locations can be protected with bollards without violating City or State regulations. This is not the majority of shelter layouts, most are built with limited space between the shelter and roadway. Locations of these shelters are sufficiently removed from the roadway that the safety benefits of installing bollards would most likely be limited.

There are approximately 1100 bus shelters throughout Miami-Dade County, and based on the inventory, 11% of bus shelter locations are possible candidates for bollards to be installed for protection. An estimate of 121 locations is a reasonable based on allowable space, however this number will decrease based on the complexity of subsurface utilities at each site.

N.T.S.



8" BOLLARD DETAIL - DCAD STANDARD

FOR PAVED AREAS

NOTES:

1.- THIS BOLLARD HAS BEEN DESIGNED FOR AN IMPACT FORCE OF 9000 POUND APPLIED AT TOP OF BOLLARD.

2.- STRENGTH OF CONCRETE 3400 PSI, 5" MAX SLUMP.

3.- MINIMUM CONCRETE COVER SHALL BE 3 INCHES.

4.- REINFORCING STEEL SHALL BE DEFORMED BAR CONFORMING TO ASTM A-615 GRADE 60.

FIGURE 7

9. PLANNING AND PERMITTING CONCERNS

According to Miami-Dade Public Works Department, cylindrical posts on a sidewalk present a hazard to motor vehicles and pedestrians. Installing bollards outside of the Clear Zone will most likely be in the middle of the sidewalk which will violate ADA requirements. Ultimately, Miami-Dade Public Works Department has jurisdiction and must approve the designs.

The typical bollard is approximately four (4) feet high and would obstruct advertisements on the shelters. Advertising firms compensate for the cost of the shelters and reducing the visibility of the ads can be compared to a loss in revenue.

Conflicts with underground utilities are a concern that must be dealt with on a site by site basis. This could increase the cost and timeline of installation. Each location can have different elements below the surface that restrict placement of the bollards. Coordination with utility owners is crucial during planning and construction phases to prevent possible conflicts and interruption of service.

The Department of Justice American with Disabilities Act (ADA) Standards for Accessible Design set guidelines for accessibility to places of public accommodation and commercial facilities of disabled persons. Section 10.2 describes the requirements of transportation facilities to accommodate users of wheelchair and mobility aids. This section states:

> *"...that bus stops, bays or other areas where a lift is to be deployed shall have a firm, stable surface; a minimum clear length of 96 inches (measured from the curb or vehicle roadway edge) and a minimum clear width of 60 inches (measured parallel to the vehicle roadway) to the maximum extent allowed by legal or site constrains; and shall be connected to streets, sidewalks or pedestrian paths by an accessible route complying with 4.3 and 4.4".*

A minimum clear width for an accessible route according to section 4.3.3 is 36 inches. Sidewalks are required to maintain a clear continuous width of 36 inches to allow for accessibility. For stations where bus routes are equipped with wheelchair lifts the guidelines require larger clear floor space. These guidelines will considerably limit the number of locations where bollards could be installed. A major concern to the implementation of a bus stop bollard protection scheme would be to maintain compliance with ADA requirements.

CONSTRUCTION COST ESTIMATE FOR INSTALLING CYLINDRICAL POST BETWEEN BUS PASSENGER BENCHES OR SHELTERS AND THE EDGE OF THE ROAD AT MIAMI-DADE TRANSIT (MDT) BUS STOPS

BOLLARDS CONSTRUCTION COST ESTIMATE PER BUS STOP LOCATION

ITEM NO.	DESCRIPTION	UNIT	Qty	UNIT PRICES	Price for Loc. With 4 bollards	Price for Loc. With 6 bollards	Price for Loc. With 8 bollards	Price for Loc. With 10 bollards	Price for Loc. With 12 bollards	Price for Loc. With 16 bollards
1	Mobilization	LS	1	$1,500.00	$1,500.00	$1,500.00	$1,500.00	$1,500.00	$1,500.00	$1,500.00
2	Maintenance of Traffic	LS	1	$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00
3	Removal of Existing Pavement	SY	1	$8.00	$32.00	$48.00	$64.00	$80.00	$96.00	$128.00
4	Concrete Sidewalk (6" thick)	SY	1	$54.42	$435.36	$653.04	$870.72	$1,088.40	$1,306.08	$1,741.44
ITEM NO.	**Installation of Bollards**									
5	8 Inches Diameter Bollards	EA	1	$300.00	$1,200.00	$1,800.00	$2,400.00	$3,000.00	$3,600.00	$4,800.00
6	Misclellaneous Concrete for Bollards Foundation	CY	0.5	$590.00	$1,180.00	$1,770.00	$2,360.00	$2,950.00	$3,540.00	$4,720.00
7	Misclellaneous Steel for Bollards Foundation	LB	100	$1.70	$680.00	$1,020.00	$1,360.00	$1,700.00	$2,040.00	$2,720.00
8	Miscellaneous Pavement Restoration	SY	1	$650.00	$2,600.00	$3,900.00	$5,200.00	$6,500.00	$7,800.00	$10,400.00
ITEM NO.	**Underground Utility Clearance**									
9	Subsurface Utility Locates	EA	1	$280.00	$1,120.00	$1,680.00	$2,240.00	$2,800.00	$3,360.00	$4,480.00
TOTAL PRICE					$10,747.36	$14,371.04	$17,994.72	$21,618.40	$25,242.08	$32,489.44

FIGURE 8

10. TIMELINE FOR INSTALLATION

Design of bollard protection for 110 locations will require approximately four (4) months. After plans are developed they must be approved by Miami-Dade County Public Works before construction can begin. Depending on the capabilities of the contractor, it would take approximately six (6) months for construction to be completed. Overall a timeline of twelve (12) months is a reasonable estimate for project completion.

11. DEVELOPMENT OF PRELIMINARY COST ESTIMATES

The construction costs of a single design will vary depending on the site conditions. A preliminary construction cost estimate is shown in Figure 8. Depending on the number of bollards, installing four (4) to sixteen (16) bollards can cost from $10,000 to $30,000 per location. This estimate does not include additional contingencies for designers and contractors which may be up to 5% of the construction costs. Subsurface utility relocation, if required, will also dramatically add to the cost of this project. At an average cost of $22,000 and only 11% of the bus shelters with allowable space to install bollards, construction costs for 121 shelters will be $2,662,000.

12. CONCLUSIONS

Findings from this feasibility analysis suggest that installation of bollards to protect bus shelters throughout Miami-Dade County creates a hazard to drivers and pedestrians. Based on Federal, State and County regulations, approximately 11% of bus shelter locations are possible candidates for a bollard retrofit, and at benches they are not recommended. Safety benefits of typical bollards are limited. They are designed as a low speed deterrent and not for high speed impacts.

A typical bollard, like those found in parking lots or adjacent to fire hydrants, cannot withstand the impact associated with errant vehicles leaving the roadway. A bollard specifically designed to withstanding high speed collisions actually increase the risk of a deadly incident as the driver or passenger of the errant vehicle are most likely to suffer serious injury.

Results from the inventory collected for this study shows that most of the benches and shelters do not have the allowable space for bollards to be installed and meet Federal, State and County design standards. Large foundations, conflicts with subsurface utilities, and approval make designs impractical to implement at most locations. It is not recommended to use cylindrical posts to provide protection at bus stops against errant vehicles that leave the roadway.

APPENDIX

Miami-Dade Transit (MDT)

EDP No. EDP-MT-MTX578119208

Scope of Services for the feasibility of installing cylindrical post between bus passenger benches or shelters and the edge of the road at about 2300 Miami-Dade Transit bus stops.

Purpose:

The Commissioners of Miami-Dade County have implemented a resolution directing the County Manager to examine the feasibility of installing cylindrical post between bus passenger benches or shelters and the edge of the road at Miami-Dade Transit (MDT) bus stops in Unincorporated Miami-Dade County. MDT requires the services of a consultant with an expertise's in traffic engineering to determine the feasibility of installing cylindrical post between bus passenger benches or shelters and the edge of the road at about 2300 Miami-Dade Transit bus stops. Study must be completed and submitted to MDT by August 31, 2007.

This report will include:

1. Meetings and Coordination.
2. Conduct Bus stop inventory for at least 300 locations county wide. Sample to be determined randomly.
3. Evaluate collected inventory data for possible installation of cylindrical post between bus passenger benches or shelters and edge of roadway. Also, this task will involve coordination with FDOT and Miami Dade Public works.
4. Performing total cost for installation of the cylindrical post including but not limited to, design, engineering, site plans.
5. Analysis of Time Schedule for implementation.
6. Evaluate Engineering, planning and permitting concerns.
7. Evaluate collected data for American with Disability Act (ADA) compliance requirements.
8. Conduct analysis of Potential safety benefits and risk for the installation of cylindrical post.
9. Development of the feasibility Study Report Draft.
10. Final Report Development and Submittal by implementing County comments from the Draft report.

C.7.f Roadside Clear Zone

The roadside clear zone is that area outside the traveled way available for use by errant vehicles. Vehicles frequently leave the traveled way during avoidance maneuvers, due to loss of control by the driver (e.g., falling asleep) or due to collisions with other vehicles. The primary function of the clear zone is to allow space and time for the driver to retain control of his vehicle and avoid or reduce the consequences of collision with roadside objects. This area also serves as an emergency refuge location for disabled vehicles.

The design of the roadway must also provide for adequate drainage of the roadway. Drainage swales within the clear zone should be gently rounded and free of discontinuities. Where large volumes of water must be carried, the approach should be to provide wide, rather than deep drainage channels. Side slopes and drainage swales that lie within the clear zone should be free of protruding drainage structures (CHAPTER 4 - ROADSIDE DESIGN, D.6.c. Culverts).

In the design of the roadside, the designer should consider the consequences of a vehicle leaving the traveled way at any location. It should always be the policy that protection of vehicles and occupants shall take priority over the protection of roadside objects. Further criteria and requirements for safe roadside design are given in CHAPTER 4 - ROADSIDE DESIGN.

C.7.f.1 Roadside Clear Zone Width

The clear zone width is defined as follows:

- Rural sections - measured from the edge of the outside motor vehicular travel way
- Urban sections - measured from the face of the curb

The minimum permitted widths are provided in Table 3 - 12. These are minimum values only and should be increased wherever practical.

In rural areas, it is desirable, and frequently economically feasible, to

TABLE 3 – 12
MINIMUM WIDTH OF CLEAR ZONE

Type of Facility	DESIGN SPEED (MPH)							
	25 and Below	30	35	40	45	50	55	60 and Above
	MINIMUM CLEAR ZONE (FEET)							
Rural •	6	6 Local 10 Collectors 14 Arterials	6 Local 10 Collectors 14 Arterials	10 Collectors 14 Arterials	14 Arterials and Collectors ADT < 1500 18 Arterials and Collectors ADT ≥ 1500	14 Arterials and Collectors ADT < 1500 18 Arterials and Collectors ADT ≥ 1500	18 Arterials and Collectors ADT < 1500 24 Arterials and Collectors ADT ≥ 1500	18 Arterials and Collectors ADT < 1500 30 Arterials and Collectors ADT ≥ 1500
Urban *	1 ½	4 **	4 **	4 **	4 **	N/A ••	N/A ••	N/A ••

* From face of curb

** On projects where the 4 foot minimum offset cannot be reasonably obtained and other alternatives are deemed impractical, the minimum may be reduced to 1 ½'.

• Use rural for urban facilities when no curb and gutter is present. Measured from the edge of through travel lane on rural section.

•• Curb and gutter not to be used on facilities with design speed > 45mph.

NOTE: ADT in Table 3 - 12 refers to Design Year ADT.

to the inability of vehicle headlights to adequately illuminate a sharply curved travel path, roadway lighting should be considered for turning roadways.

C.9.b.4 Sight Distance for Intersection Maneuvers

Sight distance is also provided at intersections to allow the drivers of stopped vehicles a sufficient view of the intersecting highway to decide when to enter or cross the intersecting highway. Sight triangles, which are specified areas along intersection approach legs and across their included corners, shall, where practical, be clear of obstructions that would prohibit a driver's view of potentially conflicting vehicles. Departure sight triangles shall be provided in each quandrant of each intersection approach controlled by stop signs. Figures 3 - 8 and 3 - 9 show typical departure sight triangles to the left and to the right of the location of a stopped vehicle on a minor road and the intersection sight distances for the various movements. Distance "a" is the length of leg of the sight triangle along the minor road. This distance is measured from the driver's eye in the stopped vehicle to the center of the nearest lane on the major road for vehicles approaching from the left, and to the center of the nearest lane for vehicles approaching from the right.

Distance "b" is the length of the leg of the sight triangle along the major road measured from the center of the minor road entrance lane. This distance is a function of the design speed and the time gap in major road traffic needed for minor road drivers turning onto or crossing the major road. This distance is calculated as follows:

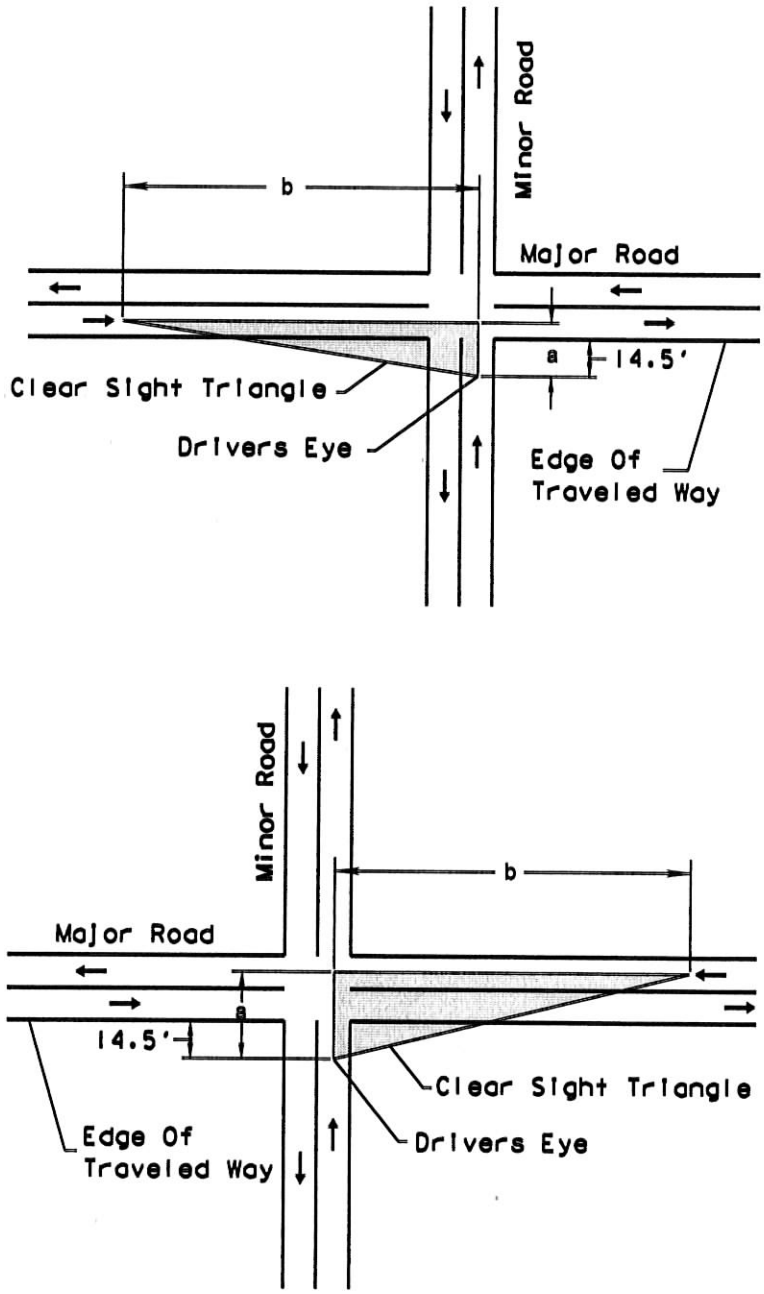
$$ISD = 1.47 V_{major} t_g$$

Where:

ISD	=	Intersection Sight Distance (ft.) – length of leg of sight triangle along the major road.
V_{major}	=	Design Speed (mph) of the Major Road
t_g	=	Time gap (sec.) for minor road vehicle to enter the major road.

Time gap values, t_g, to be used in determination of ISD are based on studies and observations of the time gaps in major road traffic actually

FIGURE 3 – 8
DEPARTURE SIGHT TRIANGLE
TRAFFIC APPROACHING FROM LEFT OR RIGHT



Francis Baluyot

From: Dean.Perkins@dot.state.fl.us
Sent: Thursday, June 14, 2007 7:17 AM
To: Francis Baluyot
Cc: akiboko@fr-aleman.com; marianne.trussell@dot.state.fl.us; Paola.Baez@dot.state.fl.us; gus.pego@dot.state.fl.us; carl.filer@dot.state.fl.us
Subject: Re: Miami-Dade Bus Shelter Protection Feasibility Study
Attachments: pic30714.gif

You can work with me or with D-6 staff. We would be glad to help.

Dean Perkins dean.perkins@dot.state.fl.us 850-414-4359
Paola Baez paola.baez@dot.state.fl.us 305-470-5333
Carl Filer carl.filer@dot.state.fl.us 305-470-5137
Gus Pego gus.pego@dot.state.fl.us 305-470-5466

Our primary concerns would be traffic safety and pedestrian accessibility. You would need to maintain the proper safety clear zones for vehicle traffic (4' behind curb & gutter, etc.) and maintain adequate clear width between sidewalk elements (4' in FDOT Design Standards.) Please contact us with your specific concerns and issues.....dp

H. Dean Perkins, Architect
ADA Coordinator
FDOT Structures Design
605 Suwannee St. MS33
Tallahassee, FL 32399-0450
Ph. 850/414-4359
Fax 850/414-4955
Email dean.perkins@dot.state.fl.us

"Nothing compares with the simple pleasure of a bike ride"
John F. Kennedy

Francis Baluyot <francis.baluyot@fr-aleman.com>
06/13/2007 04:39 PM

To <dean.perkins@dot.state.fl.us>, <marianne.trussell@dot.state.fl.us>
cc <akiboko@fr-aleman.com>
Subject Miami-Dade Bus Shelter Protection Feasibility Study

Good Afternoon.

F.R. Aleman and Associates has been sanctioned by Miami-Dade Transit (MDT) to study the feasibility of installing cylindrical posts between bus passenger or shelters and the edge of the roadway. I would like to connect with someone within District 6 to discuss accessibility regarding ADA compliance, and any concerns that arise from the installation of bollards at bus shelter locations in Miami. Any information, suggestions, or persons to contact regarding this matter would be greatly appreciated.
Have a good day.

Francis Baluyot, E.I.

(Embedded image moved to file: pic30714.gif)FRAleman

10305 NW 41 STREET, SUITE 200, MIAMI, FL 33178 | TELEPHONE: (305) 591-8777 | FAX: (305) 599-8749
http://www.fr-aleman.com

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Francis Baluyot

From: Cohen, Jeff (PWD) [jcpe@miamidade.gov]
Sent: Thursday, July 05, 2007 8:38 PM
To: Francis Baluyot
Subject: RE: MDT Bus Shelter Protection

Mr. Baluyot:
Good luck in your endeavor. I've yet to meet a cylindrical post on a sidewalk that didn't constitute a hazard to motor vehicles or pedestrians or both. If you meet the 4 ft clear zone, you'll be in the middle of the sidewalk and possibly run afoul of ADA. In my opinion, MDT needs to work with Planning & Zoning to make bus bench pads an allowable item in the landscape setback of commercial properties behind the sidewalks, and to require the property owners to permit them by amending the County Code.

Jeff Cohen, P.E., Assistant Chief
Traffic Engineering Division
Miami-Dade County Public Works Department
111 NW 1st Street • Suite 1510 • Miami, Florida 33128-1970
305-375-2030 Phone 305-372-6064 Fax
http://www.miamidade.gov/pubworks/
"Delivering Excellence Every Day"
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From: Francis Baluyot [mailto:francis.baluyot@fr-aleman.com]
Sent: Tuesday, July 03, 2007 9:43 AM
To: Cohen, Jeff (PWD)
Subject: MDT Bus Shelter Protection

Mr. Jeff Cohen,

F.R. Aleman & Associates has been sanctioned by Miami-Dade Transit to study the feasibility of installing cylindrical posts between bus passenger or shelters and the edge of the roadway. I wanted to initiate discussion on issues related to the feasibility of installing these bollards, and would like your departments input throughout the study. Primary concerns are for ADA compliance, traffic safety and pedestrian accessibility. Safe clear zones (4') and adequate sidewalk clear width (4') will be the critical measurements of our inventory. Have a good day.

Francis Baluyot, E.I.

F.R. ALEMAN
& Associates, Inc.
CONSULTING ENGINEERS & SURVEYORS

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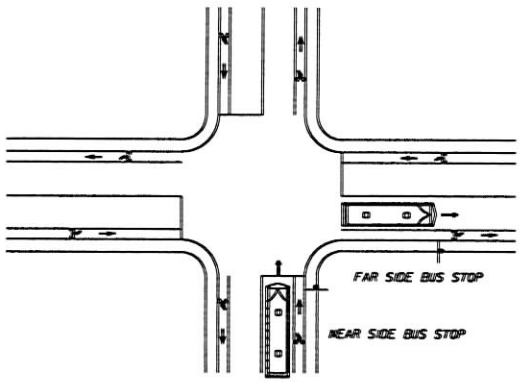
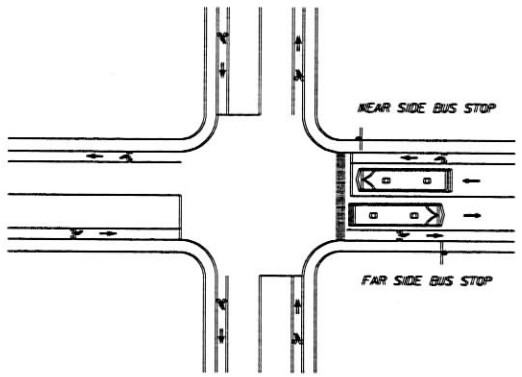
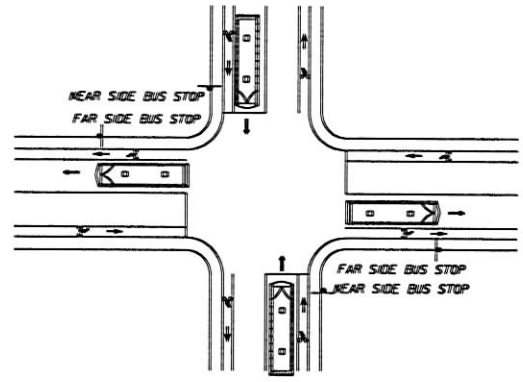
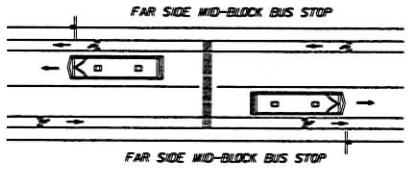
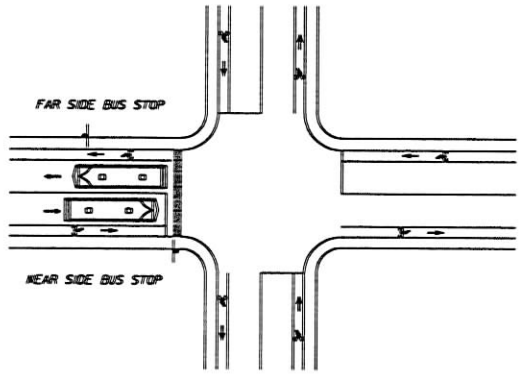
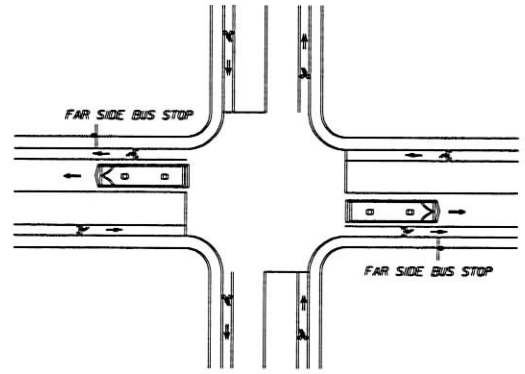


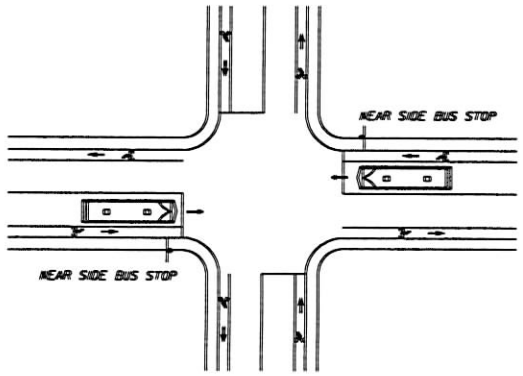












COMBINATION BUS STOP LOCATIONS

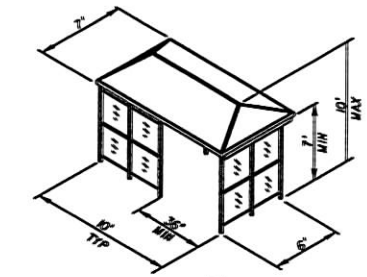
REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

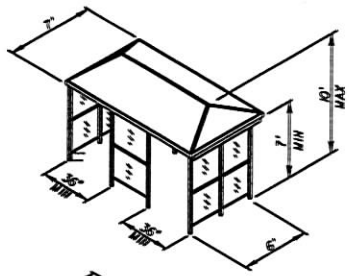
STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION		
ROAD NO.	COUNTY	FINANCIAL PROJECT ID

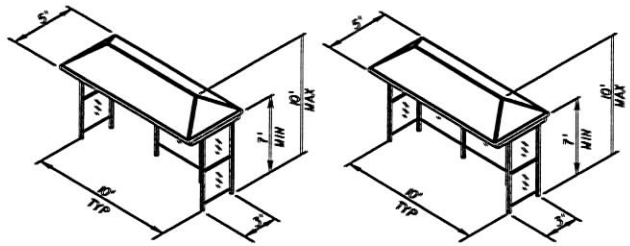
TRANSIT FACILITIES GUIDELINES
STREETSIDE COMBINATION BUS STOP LOCATIONS

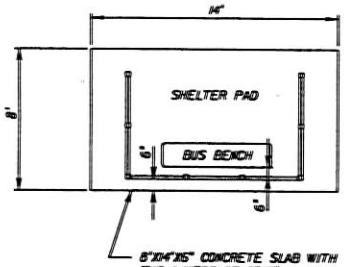
FIGURE 11-2

9/4/2005 9:07:04 AM G:\MCES\Tasks 3\ Transit safety\MPW 2 and 6\fig11-3 and trans fac drawings.dgn

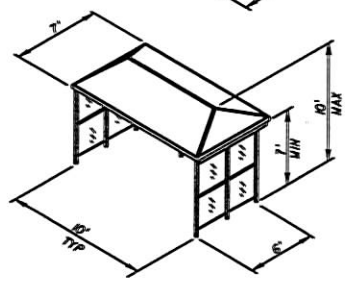




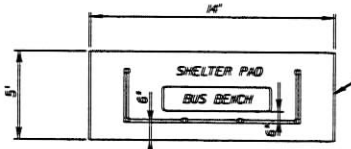




8"X104"X16" CONCRETE SLAB WITH TWO LAYERS OF 6"X6" W.W.M. ON VISQUEEN MEMBRANE AND ON WELL COMPACTED FILL (2500 PSF) TYP.

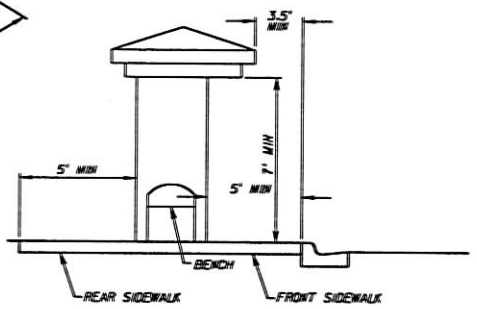


LARGE TYPICAL SHELTERS

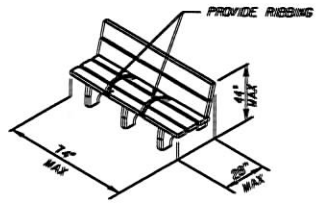


5'X104"X16" CONCRETE SLAB WITH TWO LAYERS OF 6"X6" W.W.M. ON VISQUEEN MEMBRANE AND ON WELL COMPACTED FILL (2500 PSF) TYP.

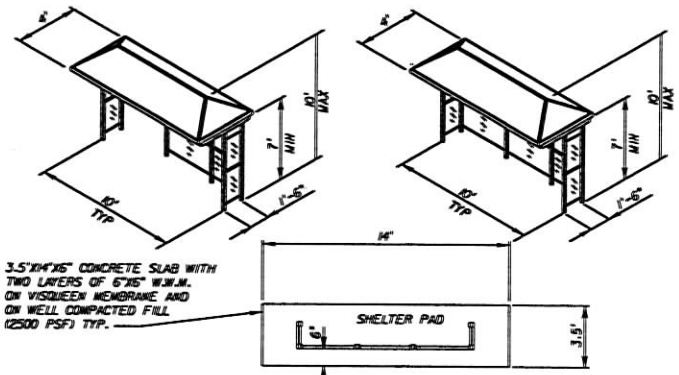
MEDIUM TYPICAL SHELTERS



MINIMUM CLEARANCES FOR SHELTERS URBAN CONDITION



BENCH DIMENSIONS



SMALL TYPICAL SHELTERS

BUS SHELTER NOTES:

- COORDINATE WITH LOCAL TRANSIT AGENCY FOR BUS SHELTER DESIGN
- BUS SHELTERS ARE PROHIBITED IN MEDIANS.
- BUS SHELTERS SHALL BE LOCATED A MINIMUM OF 12 FT FROM THE INTERSECTION POINT OF CURVE/TANGENT.
- BUS SHELTERS SHALL NOT BE LOCATED WITHIN 15 FT OF A FIRE HYDRANT OR DISABLED PARKING SPACE.
- BICYCLE RACKS SHALL BE CONSIDERED AS PART OF THE SHELTER BASED ON COORDINATION WITH THE TRANSIT AGENCY.
- A CLEAR AREA OF 2 FT MINIMUM SHOULD BE PROVIDED BEHIND SHELTER FOR MAINTENANCE.
- BICYCLE RACKS SHALL BE LOCATED SO AS NOT TO BLOCK THE VIEW OF WAITING PASSENGERS.
- BUS SHELTERS SHALL BE LOCATED AT LEAST 15 FT (DESIRABLE) AND 7 FT (MINIMUM) FROM THE NEAREST UTILITY POLE.
- STRUCTURAL DESIGN TO BE PER ALL APPLICABLE LOCAL CODES.

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID

TRANSIT FACILITIES GUIDELINES
CURBSIDE BUS SHELTER DETAILS

FIGURE
1-6

(a) at least one public entrance shall allow a person with mobility impairments to approach, enter and exit including a minimum clear door width of 32 in (815 mm).

(b) sleeping space for homeless persons as provided in the scoping provisions of 9.1.2 shall include doors to the sleeping area with a minimum clear width of 32 in (815 mm) and maneuvering space around the beds for persons with mobility impairments complying with 9.2.2(1)

(c) at least one toilet room for each gender or one unisex toilet room shall have a minimum clear door width of 32 in (815 mm), minimum turning space complying with 4.2.3, one water closet complying with 4.16, one lavatory complying with 4.19 and the door shall have a privacy latch; and, if provided, at least one tub or shower shall comply with 4.20 or 4.21 respectively.

(d) at least one common area which a person with mobility impairments can approach, enter and exit including a minimum clear door width of 32 in (815 mm).

(e) at least one route connecting elements (a), (b), (c) and (d) which a person with mobility impairments can use including minimum clear width of 36 in (915 mm), passing space complying with 4.3.4, turning space complying with 4.2.3 and changes in levels complying with 4.3.8.

(f) homeless shelters can comply with the provisions of (a)-(e) by providing the above elements on one accessible floor.

9.5.3. Accessible Sleeping Accommodations in New Construction. Accessible sleeping rooms shall be provided in conformance with the table in 9.1.2 and shall comply with 9.2 Accessible Units, Sleeping Rooms and Suites (where the items are provided). Additional sleeping rooms that comply with 9.3 Sleeping Accommodations for Persons with Hearing Impairments shall be provided in conformance with the table provided in 9.1.3

In facilities with multi-bed rooms or spaces, a percentage of the beds equal to the table provided in 9.1.2 shall comply with 9.2.2(1)

10. TRANSPORTATION FACILITIES

10.1 General. Every station, bus stop, bus stop pad, terminal, building or other transportation facility, shall comply with the applicable provisions of 4.1 through 4.35, sections 5 through 9, and the applicable provisions of this section. The exceptions for elevators in 4.1.3(5) exception 1 and 4.1.6(1)(k) do not apply to a terminal, depot, or other station used for specified public transportation, or an airport passenger terminal, or facilities subject to Title II.

10.2 Bus Stops and Terminals.

10.2.1 New Construction.

(1) Where new bus stop pads are constructed at bus stops, bays or other areas where a lift or ramp is to be deployed, they shall have a firm, stable surface; a minimum clear length of 96 inches (measured from the curb or vehicle roadway edge) and a minimum clear width of 60 inches (measured parallel to the vehicle roadway) to the maximum extent allowed by legal or site constraints; and shall be connected to streets, sidewalks or pedestrian paths by an accessible route complying with 4.3 and 4.4. The slope of the pad parallel to the roadway shall, to the extent practicable, be the same as the roadway. For water drainage, a maximum slope of 1:50 (2%) perpendicular to the roadway is allowed.

(2) Where provided, new or replaced bus shelters shall be installed or positioned so as to permit a wheelchair or mobility aid user to enter from the public way and to reach a location, having a minimum clear floor area of 30 inches by 48 inches, entirely within the perimeter of the shelter. Such shelters shall be connected by an accessible route to the boarding area provided under paragraph (1) of this section.

(3) Where provided, all new bus route identification signs shall comply with 4.30.5. In addition, to the maximum extent practicable, all new bus route identification signs shall comply with 4.30.2 and 4.30.3. Signs that are

sized to the maximum dimensions permitted under legitimate local, state or federal regulations or ordinances shall be considered in compliance with 4.30.2 and 4.30.3 for purposes of this section.

EXCEPTION: Bus schedules, timetables, or maps that are posted at the bus stop or bus bay are not required to comply with this provision.

10.2.2 Bus Stop Siting and Alterations.

(1) Bus stop sites shall be chosen such that, to the maximum extent practicable, the areas where lifts or ramps are to be deployed comply with section 10.2.1(1) and (2).

(2) When new bus route identification signs are installed or old signs are replaced, they shall comply with the requirements of 10.2.1(3).

10.3 Fixed Facilities and Stations.

10.3.1 New Construction. New stations in rapid rail, light rail, commuter rail, intercity bus, intercity rail, high speed rail, and other fixed guideway systems (e.g., automated guideway transit, monorails, etc.) shall comply with the following provisions, as applicable.

(1) Elements such as ramps, elevators or other circulation devices, fare vending or other ticketing areas, and fare collection areas shall be placed to minimize the distance which wheelchair users and other persons who cannot negotiate steps may have to travel compared to the general public. The circulation path, including an accessible entrance and an accessible route, for persons with disabilities shall, to the maximum extent practicable, coincide with the circulation path for the general public. Where the circulation path is different, signage complying with 4.30.1, 4.30.2, 4.30.3, 4.30.5, and 4.30.7(1) shall be provided to indicate direction to and identify the accessible entrance and accessible route.

(2) In lieu of compliance with 4.1.3(8), at least one entrance to each station shall comply with 4.14, Entrances. If different entrances to a station serve different transportation fixed routes or groups of fixed routes, at least one entrance serving each group or route shall comply with 4.14, Entrances. All accessible entrance shall, to the maximum extent practicable, coincide with those used by the majority of the general public.

(3) Direct connections to commercial, retail, or residential facilities shall have an accessible route complying with 4.3 from the point of connection to boarding platforms and all transportation system elements used by the public. Any elements provided to facilitate future direct connections shall be on an accessible route connecting boarding platforms and all transportation system elements used by the public.

(4) Where signs are provided at entrances to stations identifying the station or the entrance, or both, at least one sign at each entrance shall comply with 4.30.4 and 4.30.6. Such signs shall be placed in uniform locations at entrances within the transit system to the maximum extent practicable.

EXCEPTION: Where the station has no defined entrance, but signage is provided, then the accessible signage shall be placed in a central location.

(5) Stations covered by this section shall have identification signs complying with 4.30.1, 4.30.2, 4.30.3, and 4.30.5. Signs shall be placed at frequent intervals and shall be clearly visible from within the vehicle on both sides when not obstructed by another train. When station identification signs are placed close to vehicle windows (i.e., on the side opposite from boarding) each shall have the top of the highest letter or symbol below the top of the vehicle window and the bottom of the lowest letter or symbol above the horizontal mid-line of the vehicle window.

(6) Lists of stations, routes, or destinations served by the station and located on boarding areas, platforms, or mezzanines shall comply with 4.30.1, 4.30.2, 4.30.3, and 4.30.5. A minimum of one sign identifying the specific station and complying with 4.30.4 and 4.30.6 shall be provided on each platform or boarding area. All signs referenced in this paragraph shall, to the maximum extent practicable, be placed in uniform locations within the transit system.

(7)* Automatic fare vending, collection and adjustment (e.g., add-fare) systems shall comply with 4.34.2, 4.34.3, 4.34.4, and 4.34.5. At each accessible entrance such devices shall be located on an accessible route. If self-service fare collection devices are provided for the use of the general public, at least one accessible device for entering and at least one for exiting, unless one device serves both functions, shall be provided at each accessible point of entry or exit. Accessible fare collection devices shall have a minimum clear opening width of 32 in; shall permit passage of a wheelchair; and, where provided, coin or card slots and controls necessary for operation shall comply with 4.27. Gates which must be pushed open by wheelchair or mobility aid users shall have a smooth continuous surface extending from 2 inches above the floor to 27 inches above the floor and shall comply with 4.13. Where the circulation path does not coincide with that used by the general public, accessible fare collection systems shall be located at or adjacent to the accessible point of entry or exit.

(8) Platform edges bordering a drop-off and not protected by platform screens or guard rails shall have a detectable warning. Such detectable warnings shall comply with 4.29.2 and shall be 24 inches wide running the full length of the platform drop-off.

(9) In stations covered by this section, rail-to-platform height in new stations shall be coordinated with the floor height of new vehicles so that the vertical difference, measured when the vehicle is at rest, is within plus or minus 5/8 inch under normal passenger load conditions. For rapid rail, light rail, commuter rail, high speed rail, and intercity rail systems in new stations, the horizontal gap, measured when the new vehicle is at rest, shall be no greater than 3 in. For slow moving automated guideway "people mover" transit systems, the horizontal gap in new stations shall be no greater than 1 in.

EXCEPTION 1: Existing vehicles operating in new stations may have a vertical difference with respect to the new platform within plus or minus 1-1/2 in.

EXCEPTION 2: In light rail, commuter rail and intercity rail systems where it is not operationally or structurally feasible to meet the horizontal gap or vertical difference requirements, mini-high platforms, car-borne or platform-mounted lifts, ramps or bridge plates, or similar manually deployed devices, meeting the applicable requirements of 36 C.F.R. part 1192, or 49 C.F.R. part 38 shall suffice.

(10) Stations shall not be designed or constructed so as to require persons with disabilities to board or alight from a vehicle at a location other than one used by the general public.

(11) Illumination levels in the areas where signage is located shall be uniform and shall minimize glare on signs. Lighting along circulation routes shall be of a type and configuration to provide uniform illumination.

(12) Text Telephones: The following shall be provided in accordance with 4.31.9:

(a) If an interior public pay telephone is provided in a transit facility (as defined by the Department of Transportation) at least one interior public text telephone shall be provided in the station.

(b) Where four or more public pay telephones serve a particular entrance to a rail station and at least one is in an interior location, at least one interior public text telephone shall be provided to serve that entrance. Compliance with this section constitutes compliance with section 4.1.3(17)(c).

(13) Where it is necessary to cross tracks to reach boarding platforms, the route surface shall be level and flush with the rail top at the outer edge and flush with the rail top at the outer edge and between rails, except for a maximum 2-1/2 inch gap on the inner edge of each rail to permit passage of wheel flanges. Such crossings shall comply with 4.29.5. Where gap reduction is not practicable, an above-grade or below-grade accessible route shall be provided.

(14) Where public address systems are provided to convey information to the public in terminals, stations, or other fixed facilities, a means of conveying the same or equivalent information to persons with hearing loss or who are deaf shall be provided.

10.3.2 Existing Facilities: Key Stations

(15) Where clocks are provided for use by the general public, the clock face shall be uncluttered so that its elements are clearly visible. Hands, numerals, and/or digits shall contrast with the background either light-on-dark or dark-on-light. Where clocks are mounted overhead, numerals and/or digits shall comply with 4.30.3. Clocks shall be placed in uniform locations throughout the facility and system to the maximum extent practicable.

(16) Where provided in below grade stations, escalators shall have a minimum clear width of 32 inches. At the top and bottom of each escalator run, at least two contiguous treads shall be level beyond the comb plate before the risers begin to form. All escalator treads shall be marked by a strip of clearly contrasting color, 2 inches in width, placed parallel to and on the nose of each step. The strip shall be of a material that is at least as slip resistant as the remainder of the tread. The edge of the tread shall be apparent from both ascending and descending directions.

(17) Where provided, elevators shall be glazed or have transparent panels to allow an unobstructed view both in to and out of the car. Elevators shall comply with 4.10.

EXCEPTION: Elevator cars with a clear floor area in which a 60 inch diameter circle can be inscribed may be substituted for the minimum car dimensions of 4.10, Fig. 22.

(18) Where provided, ticketing areas shall permit persons with disabilities to obtain a ticket and check baggage and shall comply with 7.2.

(19) Where provided, baggage check-in and retrieval systems shall be on an accessible route complying with 4.3 and shall have space immediately adjacent complying with 4.2. If unattended security barriers are provided, at least one gate shall comply with 4.13. Gates which must be pushed open by wheelchair or mobility aid users shall have a smooth continuous surface extending from 2 inches above the floor to 27 inches above the floor.

10.3.2 Existing Facilities: Key Stations.

(1) Rapid, light and commuter rail key stations, as defined under criteria established by the Department of Transportation in subpart C of 49 CFR part 37 and existing intercity rail stations shall provide at least one accessible route from an accessible entrance to those areas necessary for use of the transportation system.

(2) The accessible route required by 10.3.2(1) shall include the features specified in 10.3.1(1), (4)-(9), (11)-(15), and (17)-(19).

(3) Where technical infeasability in existing stations requires the accessible route to lead from the public way to a paid area of the transit system, an accessible fare collection system, complying with 10.3.1(7), shall be provided along such accessible route.

(4) In light rail, rapid rail and commuter rail key stations, the platform or a portion thereof and the vehicle floor shall be coordinated so that the vertical difference, measured when the vehicle is at rest, is within plus or minus 1-1/2 inches under all normal passenger load conditions, and the horizontal gap, measured when the vehicle is at rest, is no greater than 3 inches for at least one door of each vehicle or car required to be accessible by 49 CFR part 37.

EXCEPTION 1: Existing vehicles retrofitted to meet the requirements of 49 CFR 37.93 (one-car-per-train rule) shall be coordinated with the platform such that, for at least one door, the vertical difference between the vehicle floor and the platform, measured when the vehicle is at rest with 50% normal passenger capacity, is within plus or minus 2 inches and the horizontal gap is no greater than 4 inches.

EXCEPTION 2: Where it is not structurally or operationally feasible to meet the horizontal gap or vertical difference requirements, mini-high platforms, car-borne or platform mounted lifts, ramps or bridge plates, or similar manually deployed devices, meeting the applicable requirements of 36 CFR part 1192, or 49 CFR part 38, shall suffice.

(5) New direct connections to commercial, retail, or residential facilities shall, to the maximum extent feasible, have an accessible route complying with 4.3 from the point of connection to boarding platforms and all transportation system elements used by the public. Any elements provided to facilitate future direct connections shall be on an accessible route connecting boarding platforms and all transportation system elements used by the public.

10.3.3 Existing Facilities: Alterations.

(1) For the purpose of complying with 4.1.6(2) Alterations to an Area Containing a Primary Function, an area of primary function shall be as defined by applicable provisions of 49 C.F.R. 37.43(c) (Department of Transportation's ADA Rule) or 28 C.F.R. 36.403 (Department of Justice's ADA Rule).

10.4 Airports.

10.4.1 New Construction.

(1) Elements such as ramps, elevators or other vertical circulation devices, ticketing areas, security checkpoints, or passenger waiting areas shall be placed to minimize the distance which wheelchair users and other persons who cannot negotiate steps may have to travel compared to the general public.

(2) The circulation path, including an accessible entrance and an accessible route, for persons with disabilities shall, to the maximum extent practicable, coincide with the circulation path for the general public. Where the circulation path is different, directional signage complying with 4.30.1, 4.30.2, 4.30.3 and 4.30.5 shall be provided which indicates the location of the nearest accessible entrance and its accessible route.

(3) Ticketing areas shall permit persons with disabilities to obtain a ticket and check baggage and shall comply with 7.2.

(4) Where public pay telephones are provided, and at least one is at an interior location, a public text telephone shall be provided in compliance with 4.31.9. Additionally, if four or more public pay telephones are located in any of the following locations, at least one public text telephone shall also be provided in that location:

(a) a main terminal outside the security areas;

(b) a concourse within the security areas; or

(c) a baggage claim area in a terminal.

Compliance with this section constitutes compliance with section 4.1.3(17)(c).

(5) Baggage check-in and retrieval systems shall be on an accessible route complying with 4.3 and shall have space immediately adjacent complying with 4.2.4. If unattended security barriers are provided, at least one gate shall comply with 4.13. Gates which must be pushed open by wheelchair or mobility aid users shall have a smooth continuous surface extending from 2 inches above the floor to 27 inches above the floor.

(6) Terminal information systems which broadcast information to the general public through a public address system shall provide a means to provide the same or equivalent information to persons with a hearing loss or who are deaf. Such methods may include, but are not limited to, visual paging systems using video monitors and computer technology. For persons with certain types of hearing loss such methods may include, but are not limited to, an assistive listening system complying with 4.33.7.

(7) Where clocks are provided for use by the general public the clock face shall be uncluttered so that its elements are clearly visible. Hands, numerals, and/or digits shall contrast with their background either light-on-dark or dark-on-light. Where clocks are mounted overhead, numerals and/or digits shall comply with 4.30.3. Clocks shall be placed in uniform locations throughout the facility to the maximum extent practicable.

(8) Security Systems. (Reserved).

10.5 Boat and Ferry Docks. (Reserved).

(b) Alterations to Qualified Historic Buildings and Facilities Not Subject to Section 106 of the National Historic Preservation Act. Where alterations are undertaken to a qualified historic building or facility that is not subject to section 106 of the National Historic Preservation Act, if the entity undertaking the alterations believes that compliance with the requirements for accessible routes (exterior and interior), ramps, entrances, or toilets would threaten or destroy the historic significance of the building or facility and that the alternative requirements in 4.1.7(3) should be used for the feature, the entity should consult with the State Historic Preservation Officer. If the State Historic Preservation Officer agrees that compliance with the accessibility requirements for accessible routes (exterior and interior), ramps, entrances or toilets would threaten or destroy the historical significance of the building or facility, the alternative requirements in 4.1.7(3) may be used.

(c) Consultation With Interested Persons. Interested persons should be invited to participate in the consultation process, including State or local accessibility officials, individuals with disabilities, and organizations representing individuals with disabilities.

(d) Certified Local Government Historic Preservation Programs. Where the State Historic Preservation Officer has delegated the consultation responsibility for purposes of this section to a local government historic preservation program that has been certified in accordance with section 101(c) of the National Historic Preservation Act of 1966 (16 U.S.C. 470a (c)) and implementing regulations (36 CFR 61.5), the responsibility may be carried out by the appropriate local government body or official.

(3) Historic Preservation: Minimum Requirements:

(a) At least one accessible route complying with 4.3 from a site access point to an accessible entrance shall be provided.

EXCEPTION: A ramp with a slope no greater than 1:6 for a run not to exceed 2 ft (610 mm) may be used as part of an accessible route to an entrance.

(b) At least one accessible entrance complying with 4.14 which is used by the public shall be provided.

EXCEPTION: If it is determined that no entrance used by the public can comply with 4.14, then access at any entrance not used by the general public but open (unlocked) with directional signage at the primary entrance may be used. The accessible entrance shall also have a notification system. Where security is a problem, remote monitoring may be used.

(c) If toilets are provided, then at least one toilet facility complying with 4.22 and 4.1.6 shall be provided along an accessible route that complies with 4.3. Such toilet facility may be unisex in design.

(d) Accessible routes from an accessible entrance to all publicly used spaces on at least the level of the accessible entrance shall be provided. Access shall be provided to all levels of a building or facility in compliance with 4.1 whenever practical.

(e) Displays and written information, documents, etc., should be located where they can be seen by a seated person. Exhibits and signage displayed horizontally (e.g., open books), should be no higher than 44 in (1120 mm) above the floor surface.

NOTE: The technical provisions of sections 4.2 through 4.35 are the same as those of the American National Standard Institute's document A117.1-1980, except as noted in the text.

4.2 Space Allowance and Reach Ranges.

4.2.1 * Wheelchair Passage Width. The minimum clear width for single wheelchair passage shall be 32 in (815 mm) at a point and 36 in (915 mm) continuously (see Fig. 1 and 24(e)).

4.2.2 Width for Wheelchair Passing. The minimum width for two wheelchairs to pass is 60 in (1525 mm) (see Fig. 2)

4.2.3 * Wheelchair Turning Space. The space required for a wheelchair to make a 180-degree turn is a clear space of 60 in (1525 mm)

diameter (see Fig. 3(a)) or a T-shaped space (see Fig. 3(b)).

4.2.4* Clear Floor or Ground Space for Wheelchairs.

4.2.4.1 Size and Approach. The minimum clear floor or ground space required to accommodate a single, stationary wheelchair and occupant is 30 in by 48 in (760 mm by 1220 mm) (see Fig. 4(a)). The minimum clear floor or ground space for wheelchairs may be positioned for forward or parallel approach to an object (see Fig. 4(b) and (c)). Clear floor or ground space for wheelchairs may be part of the knee space required under some objects.

4.2.4.2 Relationship of Maneuvering Clearance to Wheelchair Spaces. One full unobstructed side of the clear floor or ground space for a wheelchair shall adjoin or overlap an accessible route or adjoin another wheelchair clear floor space. If a clear floor space is located in an alcove or otherwise confined on all or part of three sides, additional maneuvering clearances shall be provided as shown in Fig. 4(d) and (e).

4.2.4.3 Surfaces for Wheelchair Spaces. Clear floor or ground spaces for wheelchairs shall comply with 4.5.

4.2.5* Forward Reach. If the clear floor space only allows forward approach to an object, the maximum high forward reach allowed shall be 48 in (1220 mm) (see Fig. 5(a)). *The minimum low forward reach is 15 in (380 mm).* If the high forward reach is over an obstruction, reach and clearances shall be as shown in Fig. 5(b).

4.2.6* Side Reach. If the clear floor space allows parallel approach by a person in a wheelchair, the maximum high side reach allowed shall be 54 in (1370 mm) and the low side reach shall be no less than 9 in (230 mm) above the floor (Fig. 6(a) and (b)). If the side reach is over an obstruction, the reach and clearances shall be as shown in Fig 6(c).

4.3 Accessible Route.

4.3.1* General. All walks, halls, corridors, aisles, *skywalks, tunnels,* and other spaces

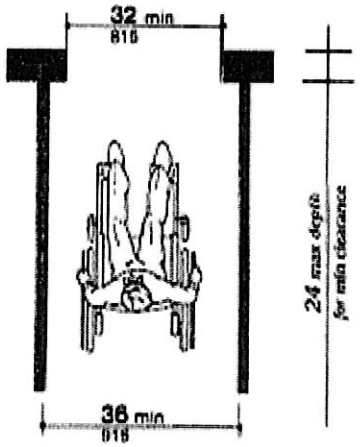


Fig. 1
Minimum Clear Width
for Single Wheelchair

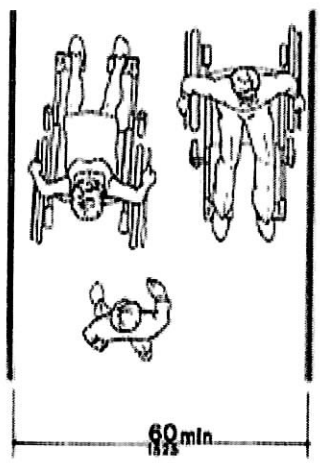


Fig. 2
Minimum Clear Width
for Two Wheelchairs

that are part of an accessible route shall comply with 4.3.

4.3.2 Location.

(1) At least one accessible route within the boundary of the site shall be provided from public transportation stops, accessible parking, and accessible passenger loading zones, and public streets or sidewalks to the accessible building entrance they serve. The accessible route shall, to the maximum extent feasible, coincide with the route for the general public.

(2) At least one accessible route shall connect accessible buildings, facilities, elements, and spaces that are on the same site.

(3) At least one accessible route shall connect accessible building or facility entrances with all accessible spaces and elements and with all accessible dwelling units within the building or facility.

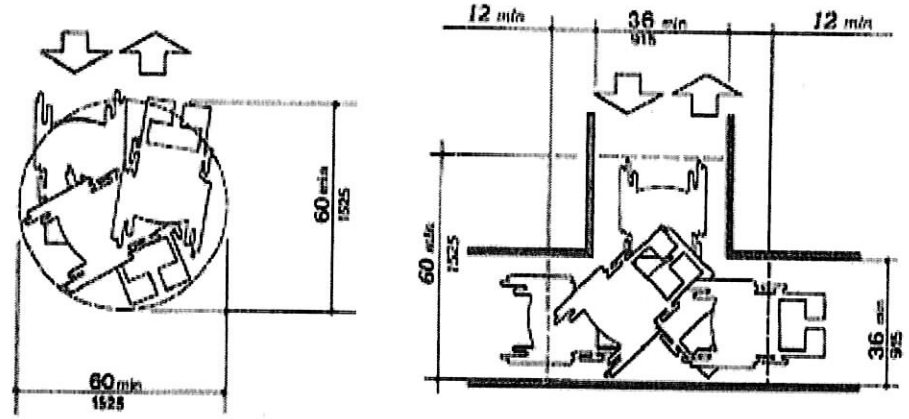
(4) An accessible route shall connect at least one accessible entrance of each accessible dwelling unit with those exterior and interior spaces and facilities that serve the accessible dwelling unit.

4.3.3 Width. The minimum clear width of an accessible route shall be 36 in (915 mm) except at doors (see 4.13.5 and 4.13.6). If a person in a wheelchair must make a turn around an obstruction, the minimum clear width of the accessible route shall be as shown in Fig. 7(a) and (b).

4.3.4 Passing Space. If an accessible route has less than 60 in (1525 mm) clear width, then passing spaces at least 60 in by 60 in (1525 mm by 1525 mm) shall be located at reasonable intervals not to exceed 200 ft (61 m). A T-intersection of two corridors or walks is an acceptable passing place.

4.3.5 Head Room. Accessible routes shall comply with 4.4.2.

4.3.6 Surface Textures. The surface of an accessible route shall comply with 4.5.

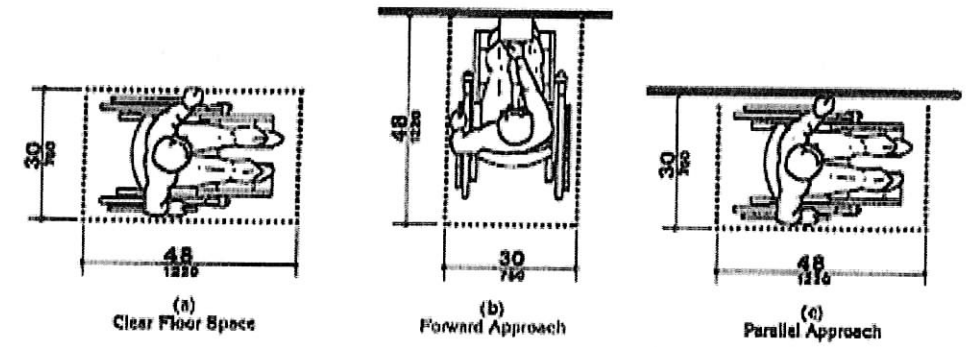


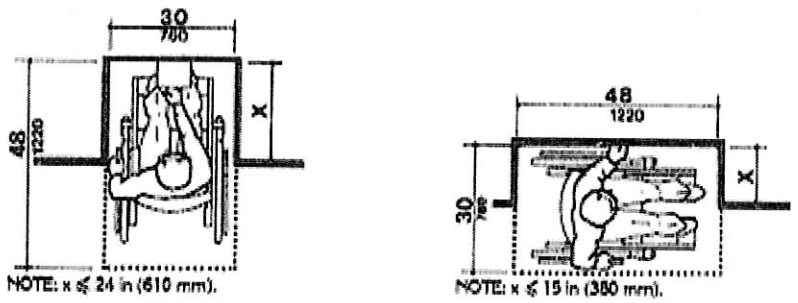
(a)
60-in (1525-mm)-Diameter Space

(b)
T-Shaped Space for 180° Turns

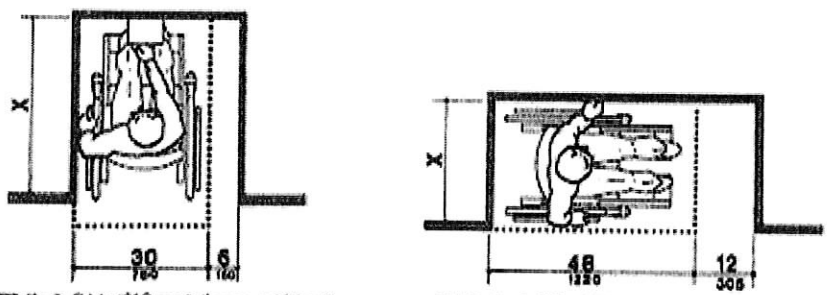
Fig. 3
Wheelchair Turning Space

45





(d)
Clear Floor Space in Alcoves



(e)
Additional Maneuvering Clearances for Alcoves

Fig. 4
Minimum Clear Floor Space for Wheelchairs

INVENTORY SHEET NO.	BUS STOP NO.	MAIN STREET/INTERSECTING STREET	DIRECTION OF TRAVEL	CORNER SIDE*	CEMUSA SHELTER NUMBER
1	MD1-0019.0100	US 1/SW # 17120	S	N	992
2	MD1-0020.0000	US 1/BANYAN ST	S	F	
3	MD1-0033.0000	US 1/SW 232 ST	S	F	
4	MD1-0037.0100	US 1/SW 264 ST	S	N	
5	MD1-0038.0000	US 1/SW 266 ST	S	F	750
6	MD1-0039.0200	US 1/SW 268 ST	S	F	
7	MD1-0041.0000	US 1/SW 272 ST	S	N	883
8	MD1-0044.0100	US 1/# 29300 (SW 293 TE)	S	N	
9	MD1-0049.0000	US 1/SW 296 ST	N	F	
10	MD1-0053.0000	US 1/SW 272 ST	N	N	1031
11	MD1-0103.0000	SW 97 AV/SW 96 ST	S	F	1084
12	MD1-0130.0000	SW 97 AV/SW 99 ST	N	N	
13	MD1-0132.0000	SW 97 AV/SW 94 ST	N	N	1036
14	MD1-0166.0000	SW 107 AV/SW 96 ST	N	F	373
15	MD1-0214.0000	SW 112 AV/SW 161 TE	S	N	925
16	MD1-0217.0090	SW 112 AV/SW 211 ST	S	F	785
17	MD1-0221.0400	SW 112 AV/SW 224 ST	N	F	757
18	MD1-0226.0000	SW 112 AV/SW 167 ST	N	F	
19	MD1-0237.0500	SW 117 AV/SW 95 ST	S	F	635
20	MD1-0245.0000	SW 117 AV/SW 186 ST	S	N	679
21	MD1-0255.0000	SW 117 AV/SW 187 TE	N	F	49
22	MD1-0263.0000	SW 117 AV/SW 131 ST	N	N	
23	MD1-0274.0070	SW 122 AV/SW 144 ST	S	F	854
24	MD1-0274.0680	SW 122 AV/SW 195 TE	N	F	974
25	MD1-0507.0000	SW 104 ST/SW 113 PL	W	N	349
26	MD1-0508.0400	SW 104 ST/SW 132 AV	W	N	929
27	MD1-0508.0620	SW 104 ST/SW 139 AV	W	F	
28	MD1-0508.0710	SW 104 ST/SW 148 AV	W	F	99
29	MD1-0508.1400	SW 104 ST/SW 122 AV	E	F	874
30	MD1-0514.0000	SW 107 ST/SW 109 CT	W	F	
31	MD1-0519.0150	SW 112 ST/SW 107 AV	W	F	628
32	MD1-0521.0000	SW 112 ST/SW 112 AV	W	N	
33	MD1-0523.0100	SW 112 ST/SW 107 AV	E	N	
34	MD1-0527.0000	SW 112 ST/# 9890	E	N	
35	MD1-0527.0082	SW 136 ST/SW 97 AV	W	F	1104
36	MD1-0527.0083	SW 136 ST/SW 99 PL	W	N	S-1105
37	MD1-0527.0700	SW 144 ST/SW 122 AV	E	F	967
38	MD1-0539.0000	SW 152 ST/SW 104 AV	W	N	
39	MD1-0540.0020	SW 152 ST/SW 117 AV	W	N	730
40	MD1-0540.0040	SW 152 ST/SW 129 AVE	W	F	
41	MD1-0543.0050	SW 152 ST/SW 99 CT	E	N	734
42	MD1-0543.0100	SW 152 ST/SW 97 AV	E	N	
43	MD1-0552.0000	SW 160 ST/SW 142 AV	E	F	
44	MD1-0554.0100	SW 160 ST/SW 139 AV	W	N	649
45	MD1-0565.0000	SW 168 ST/SW 107 AV	W	N	664
46	MD1-0575.0000	SW 168 ST/SW 105 AV	E	N	736
47	MD1-0577.0200	SW 172 ST/SW 102 AV	W	N	
48	MD1-0594.0100	SW 184 ST/SW 112 AV	W	F	48
49	MD1-0598.0000	SW 184 ST/SW 119 AV	E	N	
50	MD1-0600.0000	SW 184 ST/SW 112 AV	E	N	1122
51	MD1-0611.0200	SW 192 ST/SW 113 PL	E	F	693
52	MD1-0616.0500	SW 197 ST/SW 113 AV	W	F	698
53	MD2-0058.0000	SW 107 AV/SW 11 ST	S	N	320
54	MD2-0066.0400	SW 107 AV/SW 64 ST	S	N	1120
55	MD2-0071.0000	SW 107 AV/SW 84 ST	S	N	701
56	MD2-0079.0300	SW 107 AV/SW 66 ST	N	N	64
57	MD2-0097.0000	SW 112 AV/SW 32 ST	S	F	335
58	MD2-0119.0000	SW 112 AV/SW 40 ST	N	F	82
59	MD2-0126.0000	SW 117 AV/SW 72 ST	S	F	130
60	MD2-0126.0070	SW 117 AV/SW 88 ST	S	N	129

TABLE 1 (Page 1 of 5)

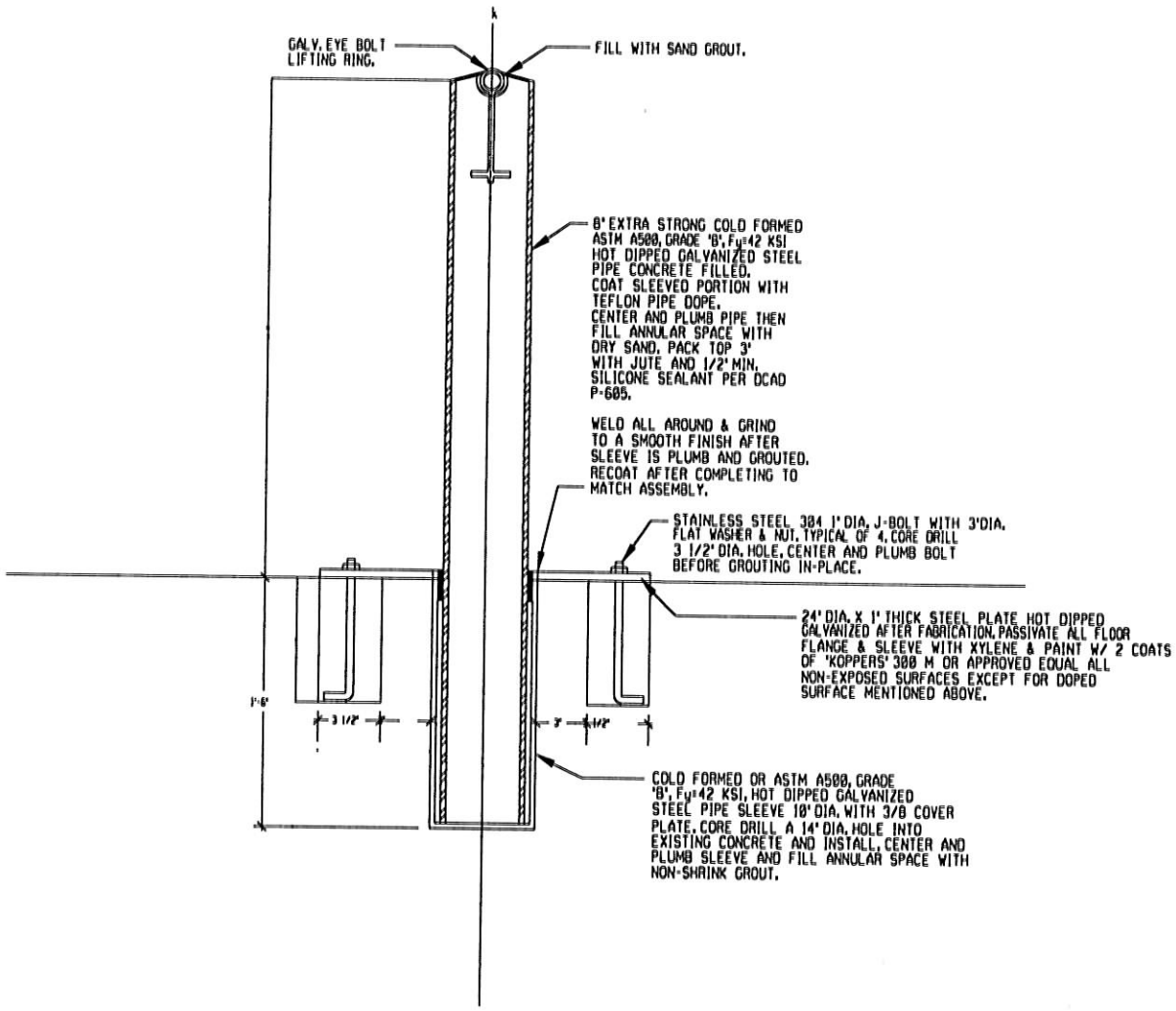
61	MD2-0132.0300	SW 122 AV/SW 34 ST	N	F	857
62	MD2-0139.0000	SW 127 AV/SW 40 ST	N	N	63
63	MD2-0179.0000	SW 137 AV/SW 74 ST	S	N	454
64	MD2-0182.0500	SW 137 AV/SW 84 ST	S	F	995
65	MD2-0206.0555	SW 147 AV/SW 88 ST	N	F	1165
66	MD2-0206.0580	SW 147 AV/SW 63 TE	N	F	1149
67	MD2-0206.0650	SW 147 AV/SW 45 ST	N	F	1029
68	MD2-0207.5000	SW 152 AV/SW 80 ST	N	F	597
69	MD2-0554.0010	SW 26 ST/SW 124 AV	W	F	937
70	MD2-0554.0520	SW 26 ST/SW 137 AV	W	N	328
71	MD2-0554.0535	SW 26 ST/SW 149 AV	W	N	952
72	MD2-0554.0550	SW 26 ST/SW 137 AV	E	F	77
73	MD2-0554.0590	SW 26 ST/SW 132 AV	E	N	319
74	MD2-0558.0200	SW 32 ST/SW 109 AV	W	F	764
75	MD2-0559.0200	SW 32 ST/SW 107 AV	E	N	
76	MD2-0562.0000	SW 34 ST/SW 123 CT	W	N	
77	MD2-0574.0000	SW 40 ST/SW 88 CT	W	F	
78	MD2-0590.0000	SW 40 ST/SW 110 AV	W	N	
79	MD2-0595.0000	SW 40 ST/FLORIDA TURNPIKE	W	F	973
80	MD2-0603.0000	SW 40 ST/SW 112 AV	E	F	172
81	MD2-0604.0000	SW 40 ST/SW 110 AV	E	F	
82	MD2-0605.0000	SW 40 ST/SW 108 AV	E	F	
83	MD2-0606.0000	SW 40 ST/SW 107 AV	E	F	
84	MD2-0607.0100	SW 40 ST/SW 103 CT	E	N	901
85	MD2-0610.0000	SW 40 ST/SW 98 AV	E	F	1142
86	MD2-0614.0000	SW 40 ST/SW 92 AV	E	N	
87	MD2-0617.0000	SW 40 ST/SW 88 CT	E	N	
88	MD2-0619.0000	SW 42 ST/SW 124 AV	W	F	234
89	MD2-0621.0005	SW 42 ST/SW 127 AV	W	F	243
90	MD2-0621.0010	SW 42 ST/SW 129 AV	W	N	
91	MD2-0621.0020	SW 42 ST/SW 132 AV	W	N	244
92	MD2-0621.0060	SW 42 ST/SW 144 AV	W	N	260
93	MD2-0621.0100	SW 42 ST/SW 127 AV	E	F	249
94	MD2-0623.0000	SW 47 ST/SW 137 AV	W	F	
95	MD2-0639.0000	SW 56 ST/SW 88 PL	W	N	210
96	MD2-0641.0000	SW 56 ST/SW 92 AV	W	N	
97	MD2-0644.0070	SW 56 ST/SW 117 AV	W	N	
98	MD2-0644.0300	SW 56 ST/SW 132 AV	W	N	
99	MD2-0644.0650	SW 56 ST/SW 147 AV	W	N	216
100	MD2-0647.0060	SW 56 ST/SW 135 AV	E	N	
101	MD2-0647.0150	SW 56 ST/SW 122 AV	E	N	54
102	MD2-0647.0300	SW 56 ST/SW 104 AV	E	F	200
103	MD2-0649.0000	SW 56 ST/SW 99 PL	E	F	40
104	MD2-0650.0000	SW 56 ST/SW 98 AV	E	N	202
105	MD2-0679.0000	SW 72 ST/SW 147 AV	W	N	
106	MD2-0679.0800	SW 72 ST/SW 144 PL	E	F	219
107	MD2-0686.0200	SW 72 ST/SW 127 AV	E	F	266
108	MD2-0686.0730	SW 72 ST/OP # 10855	E	N	100
109	MD2-0690.0000	SW 72 ST/SW 98 CT	E	N	58
110	MD2-0693.0000	SW 72 ST/SW 92 AV	E	F	
111	MD2-0701.0100	SW 88 ST/ # 8841	W	F	
112	MD2-0703.0000	SW 88 ST/SW 91 AV	W	F	96
113	MD2-0708.0000	SW 88 ST/SW 99 CT	W	F	
114	MD2-0712.0000	SW 88 ST/SW 103 AV	W	N	
115	MD2-0729.1000	SW 88 ST/SW 147 AV	E	N	
116	MD2-0737.0000	SW 88 ST/SW 112 PL	E	N	
117	MD3-0108.0000	SW 42 AV/SW 8 ST	S	F	
118	MD3-0123.0000	SW 57 AV/SW 34 ST	S	N	340
119	MD3-0134.0000	SW 57 AV/SW 60 ST	S	N	1166
120	MD3-0157.0000	SW 57 AV/SW 76 ST	N	N	S-896
121	MD3-0163.0500	SW 67 AV/SW 12 ST	S	N	940
122	MD3-0163.0600	SW 67 AV/SW 14 ST	S	N	
123	MD3-0165.0000	SW 67 AV/SW 18 ST	S	N	543
124	MD3-0174.0300	SW 67 AV/SW 40 ST	S	F	325
125	MD3-0177.0000	SW 67 AV/SW 51 TE	S	N	341

126	MD3-0201.0000	SW 67 AV/SW 32 ST	N	N	941
127	MD3-0261.0000	SW 82 AV/SW 8 ST	S	F	199
128	MD3-0273.0200	SW 82 AV/SW 24 ST	N	F	331
129	MD3-0279.0000	SW 87 AV/W FLAGLER ST	S	F	323
130	MD3-0289.0000	SW 87 AV/SW 21 TE	S	F	311
131	MD3-0307.0000	SW 87 AV/SW 56 ST	S	F	315
132	MD3-0313.0000	SW 87 AV/SNAPPER CREEK EXPRWY	S	N	1156
133	MD3-0506.0000	W FLAGLER ST/NW 82 AV	W	F	17
134	MD3-0520.0115	SW 8 ST/SW 84 AV	E	F	
135	MD3-0520.0125	SW 8 ST/SW 80 CT	E	F	
136	MD3-0520.0150	SW 8 ST/SW 75 AV	E	N	922
137	MD3-0520.0450	SW 8 ST/SW 67 AV	E	N	403
138	MD3-0545.0000	SW 24 ST/SW 82 AV	W	F	931
139	MD3-0546.0000	SW 24 ST/SW 84 AV	W	F	932
140	MD3-0547.0000	SW 24 ST/# 8585 (BARNETT BK)	W	N	
141	MD3-0554.0000	SW 24 ST/SW 79 AV	E	N	
142	MD3-0555.0000	SW 24 ST/SW 77 CT	E	N	
143	MD3-0558.0000	SW 24 ST/SW 72 AV	E	N	996
144	MD3-0561.0000	SW 24 ST/SW 67 AV	E	N	
145	MD3-0565.0000	SW 24 ST/SW 60 CT	E	N	
146	DOR-1180.0000	NW 17 ST/NW 87 AV	E	F	107
147	MD4-0016.0000	NW 7 AV/NW 83 ST	N	F	140
148	MD4-0020.0000	NW 7 AV/NW 94 ST	N	N	
149	MD4-0028.0000	NW 7 AV/NW 97 ST	S	N	390
150	MD4-0031.0000	NW 7 AV/NW 90 ST	S	N	143
151	MD4-0042.0000	NW 17 AV/NW 75 ST	N	F	122
152	MD4-0049.0000	NW 17 AV/NW 87 ST	N	N	840
153	MD4-0053.0600	NW 17 AV/NW 95 ST	S	N	
154	MD4-0081.0000	NW 22 AV/NW 56 ST	N	N	
155	MD4-0088.0000	NW 22 AV/NW 71 ST	N	N	
156	MD4-0102.0000	NW 22 AV/NW 100 ST	N	F	
157	MD4-0117.0000	NW 22 AV/NW 79 ST	S	F	
158	MD4-0127.0000	NW 22 AV/NW 56 ST	S	N	
159	MD4-0152.0000	NW 27 AV/NW 58 ST	N	N	
160	MD4-0161.0000	NW 27 AV/NW 79 TE	N	N	
161	MD4-0162.0000	NW 27 AV/NW 80 ST	N	F	196
162	MD4-0174.0000	NW 27 AV/NW 100 ST	S	F	317
163	MD4-0203.0000	NW 27 AV/NW 32 ST	S	N	81
164	MD4-0224.0000	NW 32 AV/NW 65 ST	N	F	
165	MD4-0247.0000	NW 32 AV/NW 99 ST	S	F	
166	MD4-0252.0000	NW 32 AV/NW 87 ST	S	N	
167	MD4-0277.0000	NW 32 AV/NW 34 ST	S	F	955
168	MD4-0328.0000	NW 72 AV/NW 31 ST	S	F	
169	MD4-0331.0000	NW 72 AV/# 2200	S	F	808
170	MD4-0332.0000	NW 72 AV/NW 16 ST	S	F	809
171	MD4-0335.0100	NW 72 AV/NW 4 ST	S	F	
172	DOR-1225.0000	NW 19 ST/NW 102 AV	E	F	
173	MD4-0504.0000	NW 103 ST/NW 32 AV	E	F	
174	MD4-0512.0100	NW 103 ST/NW 12 AV	E	N	
175	MD4-0516.0000	NW 103 ST/NW 27 AV	W	F	
176	MD4-0530.0000	NW 95 ST/NW 14 AV	E	F	
177	MD4-0533.0000	NW 95 ST/NW 10 AV	E	F	1052
178	MD4-0535.0000	NW 95 ST/NW 7 AV	E	N	463
179	MD4-0540.0000	NW 95 ST/NW 5 CT	W	F	
180	MD4-0545.0000	NW 95 ST/# 1225	W	F	1053
181	MD4-0547.0000	NW 95 ST/NW 19 AV	W	N	
182	MD4-0553.0000	NW 79 ST/NW 33 AV	E	F	76
183	MD4-0556.0000	NW 79 ST/NW 27 AV	E	F	
184	MD4-0571.0000	NW 79 ST/NW 10 CT	E	N	572
185	MD4-0577.0000	NW 79 ST/NW 12 PL	W	N	574
186	MD4-0585.0100	NW 79 ST/NW 23 AV	W	N	16
187	MD4-0598.0000	NW 71 ST/NW 21 AV	E	N	869
188	MD4-0607.0000	NW 71 ST/NW 14 AV	W	N	871
189	MD4-0608.0000	NW 71 ST/NW 15 AV	W	N	842
190	MD4-0616.0000	NW 62 ST/NW 22 AV	E	F	125

191	MD4-0628.0000	NW 62 ST/NW 32 AV	W	N	
192	MD4-0643.1000	NW 54 ST/NW 32 AV	W	F	137
193	MD4-0687.0000	NW 36 ST/NW 66 AV	E	F	641
194	MD4-0693.0000	NW 36 ST/# 5600	E	N	438
195	MD4-0697.0000	NW 36 ST/LA VILLA DR	E	F	439
196	MD4-0699.0000	NW 36 ST/MILLER DR	E	M	
197	MD4-0709.0925	NW 7 ST/NW 111 PL	W	N	69
198	MD4-0709.1330	NW 6 ST/NW 128 PL	W	F	754
199	MD4-0709.1450	NW 6 ST/NW 124 AV	E	N	
200	MD4-0710.0950	W FLAGLER ST/SW 102 AV	E	F	191
201	MD4-0712.0000	W FLAGLER ST/SW 97 AV	E	N	
202	MD4-0716.0000	W FLAGLER ST/SW 92 AV	E	F	334
203	MD4-0735.0000	W FLAGLER ST/NW 109 AV	W	F	
204	MD4-0737.0000	W FLAGLER ST/# 11495	W	N	35
205	MD5-0001.0000	COLLINS AV/HAULOVER PIER	N	N	1121
206	MD5-0003.0000	COLLINS AV--OP/HAULOVER CLUB HOUSE	N	M	946
207	MD5-0004.0500	COLLINS AV/OP # 15000(BOAT RAMP	N	N	1126
208	MD5-0049.0000	COLLINS AV/HAULOVER MARINA	S	N	938
209	MD5-0056.0000	BISCAYNE BD/NE 108 ST	N	N	1136
210	MD5-0060.0000	BISCAYNE BD/NE 116 ST	N	N	1055
211	MD5-0073.0000-A	BISCAYNE BD/# 10700	S	F	1123
212	MD5-0094.0000	NE 6 AV/NE 154 ST	N	N	709
213	MD5-0095.0000	NE 6 AV/NE 157 ST	N	N	710
214	MD5-0099.0200	NE 6 AV/NE 166 ST	S	F	
215	MD5-0107.0060	NE 2 AV/NE 108 ST	N	F	
216	MD5-0107.0090	NE 2 AV/NE 114 ST	N	N	843
217	MD5-0148.0000	NW 7 AV/NW 109 ST	N	N	145
218	MD5-0149.0000	NW 7 AV/NW 111 ST	N	F	
219	MD5-0161.0000	NW 7 AV/NW 156 ST	N	N	
220	MD5-0172.0000	NW 7 AV/NW 139 ST	S	F	
221	MD5-0196.0000	NW 17 AV/NW 103 ST	N	F	
222	MD5-0210.0000	NW 17 AV/NW 117 ST	S	N	1117
223	MD5-0211.0000	NW 17 AV/NW 116 ST	S	N	1118
224	MD5-0222.0000	NW 22 AV/NW 103 ST	N	F	
225	MD5-0253.0000	NW 22 AV/NW 119 ST	S	F	
226	MD5-0263.0100	NW 27 AV/NW 116 ST	N	F	
227	MD5-0284.0100	NW 27 AV/NW 116 ST	S	N	29
228	MD5-0504.0000	NW 119 ST/NW 27 AV	E	F	
229	MD5-0512.0000	NW 119 ST/NW 10 AV	E	N	
230	MD5-0515.0000	NW 119 ST/NW 5 AV	E	F	
231	MD5-0517.0000	NE 119 ST/N MIAMI AV	E	F	844
232	MD5-0520.0000	NW 119 ST/NW 2 AV	W	F	
233	MD5-0524.0000	NW 119 ST/NW 19 AV	W	F	26
234	MD5-0537.0000	NW 135 ST/NW 24 AV	E	F	678
235	MD6-0027.0000	W DIXIE HY/NE 199 ST	S	N	1137
236	MD6-0030.0000	W DIXIE HY/NE 26 AV	S	N	

237	MD6-0036.0000	W DIXIE HY/NE 186 TE	N	F	
238	MD6-0047.0000	NE 22 AV/NE 191 ST	S	F	584
239	MD6-0056.0000	NE 19 AV/NE 185 ST	S	F	
240	MD6-0056.0010	NE 18 AV/NE 199 ST	S	F	588
241	MD6-0061.0000	NE 14 AV/NE 185 ST	N	F	619
242	MD6-0062.0000	NE 14 AV/# 18707	N	N	600
243	MD6-0065.0000	NE 14 AV/# 18900	S	F	620
244	MD6-0065.0200	NE 14 AV/OP # 18707	S	F	
245	MD6-0065.0400	NE 14 AV/NE 185 ST	S	N	670
246	MD6-0082.0100	NE 10 AV/NE 167 ST	N	F	
247	MD6-0085.0100	NE 10 AV/NE 199 ST (WOOD RDG)	N	F	73
248	MD6-0086.0000	NE 10 AV RD/NE 205 TE	N	N	
249	MD6-0088.0000	NE 10 AV/NE 199 ST	S	N	658
250	MD6-0089.0100	NE 10 AV/NE 173 ST	S	N	660
251	MD6-0091.1200	NE 2 AV/NE 183 ST	N	F	576
252	MD6-0095.0000	NE 2 AV/NE 191 ST	N	N	426
253	MD6-0102.0000	NE 2 AV/NE 214 ST	N	N	
254	MD6-0112.0000	NE 2 AV/NE 183 ST	S	N	798
255	MD6-0282.0200	NW 47 AV/NW 168 TE	S	F	
256	MD6-0292.0200	NW 57 AV/NW 170 TE	N	N	
257	MD6-0294.0000	NW 67 AV/NW 169 ST	N	N	
258	MD6-0294.0021	NW 67 AV/NW 186 ST	N	F	221
259	MD6-0305.0200	NW 82 AV/NW 191 ST	S	F	904
260	MD6-0522.0700	NW 174 ST/NW 67 AV	E	N	905
261	MD6-0558 0000	NW 186 ST/NW 84 CT	E	N	1159
262	MD6-0560.0070	NW 186 ST/NW 82 AV	E	F	413
263	MD6-0560.0072	NW 186 ST/NW 79 AV	E	N	415
264	MD6-0560.0074	NW 186 ST/WENTWORTH DR	E	F	638
265	MD6-0561.0000	NW 183 ST/NW 57 AV	E	F	
266	MD6-0562.0000	NW 183 ST/NW 55 AV	E	F	538
267	MD6-0598.0100	NE 185 ST/NE 18 AV	E	N	416
268	MD6-0605.0000	NE 186 ST/ W DIXIE HY	W	F	
269	MD6-0612.0000	NE 185 ST/NE 15 AV	W	F	464
270	MD6-0614.0400	NE 185 ST/NE 4 CT	E	N	838
271	MD6-0695.0000	CALIFORNIA DR/OP # 441	S	F	560
272	MD6-0695.0020	NE 195 ST/# 626	E	F	1103
273	MD6-0695.0040	NE 195 ST/# 800	E	N	581
274	MD6-0695.0050	NE 195 ST/10 AV	E	N	569
275	MD6-0702.0080	HONEY HILL RD/NW 55 AV	E	N	482
276	MD6-0702.0100	NW 199 ST/NW 52 AV	E	N	478
277	MD6-0702.0200	NW 199 ST/NW 49 CT	E	F	479
278	MD6-0711.0100	NE 199 ST/# 760	E	F	561
279	MD6-0711.0200	NE 199 ST/# 900	E	N	559
280	MD6-0711.0300	NE 199 ST/NE 10 AV	E	N	579
281	MD6-0718.0083	HONEY HILL RD/NW 55 PL	W	N	480
282	MD6-0719.1100	NE 203 ST/NE 26 AV	W	F	
283	MD6-0719.1200	NE 203 ST/NE 21 AV	W	N	178
284	MD6-0719.1300	NE 203 ST/NE 20 AV	W	N	522
285	MD6-0725.0000	NE 205 TE/NE 11 AV	E	N	
286	MD6-0726.0000	NE 205 TE/NE 12 AV	E	F	
287	MD6-0730.0000	NE 205 TE/NE 15 AV	W	N	919
288	MD6-0732.0000	NE 205 TE/NE 13 AV	W	N	939
289	DOR-0050.0000	NW 79 AV/NW 41 ST	S	N	
290	DOR-0130.0000	NW 87 AV/NW 29 ST	N	F	
291	DOR-0336.0000	NW 107 AV/NW 27 ST	S	N	
292	DOR-0625.0000	NW 41 ST/NW 107 AV	E	F	
293	DOR-0638.0000	NW 41 ST/NW 97 AV	E	N	
294	DOR-0690.0000	NW 36 ST/NW 79 AV	E	N	
295	DOR-0735.0000	NW 36 ST/NW 84 BLK	W	F	
296	DOR-0762.0000	NW 41 ST/NW 102 AV	W	F	
297	DOR-0820.0000	NW 25 ST/NW 79 AV	W	F	
298	DOR-0935.0000	NW 25 ST/NW 82 AV	E	N	
299	DOR-0985.0000	NW 21 TE/NW 87 AV	E	N	
300	DOR-0900.0000	NW 25 ST/NW 99 AV	E	N	284

N.T.S.



8" BOLLARD DETAIL - FLANGED SLEEVE

FOR CONCRETE APRON AREAS

NOTES:

1.- MAINTAIN A 4'8" CLEARANCE BETWEEN FACE OF DISCONNECT SWITCH AND BOLLARDS IN ALL BOARDING BRIDGE PIVOT BASE STANDS. WHERE FIELD CONDITIONS PERMIT, LOCATE FACE OF DISCONNECT SWITCH AT THE CENTER OF THE 4.31' CLEARANCE BETWEEN BOLLARDS.

SD-STD-02.01, Revision A, March 2003

Test Method for Vehicle Crash Testing of Perimeter Barriers and Gates

This standard is issued by the U.S. Department of State, Bureau of Diplomatic Security, Office of Physical Security Programs, Physical Security Division, SA-14, Washington, D.C. 20520-1403. Copies of this Standard may be obtained from this office. Revision A replaces SD-STD-02.01, April 1985, in its entirety.

1. Scope

1.1. Only the Bureau of Diplomatic Security may determine and assign certification ratings for anti-ram barriers. The test method described herein provides specified levels of vehicle impact resistance required by the U.S. Department of State (DOS) Bureau of Diplomatic Security (DS) to select appropriate perimeter barriers and gates for use at DOS facilities. Many test parameters are standardized to arrive at a single vehicle type and mass, enhance test realism and replication, and produce consistent rating designations.

1.2. Compliance with these rating designations establishes a measure of performance, but does not render any perimeter barrier or gate invulnerable to vehicle penetration. Caution should be exercised in interpreting test findings and projecting results to other hypothetical conditions. Developers and user agencies are encouraged to continue beyond these test conditions and address specific or unusual site conditions as needed.

1.3. Product/design certification under this Standard only addresses the ability of the barrier to withstand the impact of the test vehicle. It does not represent an endorsement of the product/design or address its operational suitability.

2. Referenced Documents

2.1. "Specification for Vehicle Crash Test of Perimeter Barriers and Gates," SD-STD-02.01, Physical Security Division, U.S. Department of State, April 1985.

3. Background

3.1. Since this Standard was first published in 1985, the frequency and scale of terrorist attacks have increased. Global incidents and testing manifest a need for updated vehicle configuration and performance prerequisites, and more stringent penetration limitations.

3.2. *Updated vehicle characteristics*:

3.2.1. This revised Standard continues to use medium duty trucks as test vehicles. They carry a credible payload to threaten diplomatic facilities. Smaller vehicles than the medium duty category are limited in cargo weight and volume; they are also less likely to succeed in ramming barriers designed for medium duty trucks due to their smaller mass, lower height, and frame construction. Larger, heavy duty trucks are more conspicuous, more difficult to operate, need longer distances to accelerate, and, if carrying larger charge weights consistent with their capacity, do not need to ram given typical setbacks.

3.2.2. Newer medium duty trucks have dimensional changes, such as rail height, that impact barrier effectiveness. A critical factor in barrier effectiveness is whether the engine is gasoline or diesel. This revision requires anti-ram testing with diesel powered trucks, which have associated vehicle characteristics that distinguish their dynamic response from gasoline engines.

3.2.3. Payload attachment has also been interpreted inconsistently in testing to date. This includes unrealistic welding of cargo to the truck rails, creating fully rigid interactive elements with the barrier. This revision requires firm attachment to a cargo bed to ensure the cargo realistically transfers its kinetic energy to the impact process.

3.2.4. Vehicle speed is a primary factor since kinetic energy is a function of the square of the velocity ($KE = \frac{1}{2} mv^2$). 50 kph (30 mph) is achievable in most urban area conditions and vehicle accessible perimeter areas will be protected at least to this minimum nominal impact speed. Urban terrain makes speeds greater than 80 kph (50 mph) difficult to achieve for a medium duty truck. The sensitivity of vehicle impact energy to velocity warrants a mid-

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range speed of 65 kph (40 mph) barrier for many perimeter sectors.

3.3. *Penetration limitations*:

3.3.1. Previous penetration measurements were from the *outside* of the perimeter barrier. This differs from the Overseas Policy Board (OSPB) defined setback measured from *inside* the perimeter barrier. For consistency, the new penetration definition is measured from inside the perimeter barrier.

3.3.2. Vehicle penetration distance was previously measured at the leading edge of the vehicle, which can result in conditions where the truck may have penetrated, yet the cargo may not have crossed the perimeter. Cargo bed penetration is the relevant parameter; therefore, the new criteria for penetration measurement is at the leading edge of the cargo bed.

3.3.3. New construction must have a minimum 30 meter setback; the structure is designed for blast protection at this setback. If greater or lessor setback is available, the blast design is adjusted accordingly.

3.3.4. Most existing facilities have setback significantly less than 30 meters.

3.3.5. For both new construction and existing facilities, permissible penetration must be extremely limited. At pressure levels DOS must protect against, one meter of penetration into 30 meters setback increases blast loading approximately 9%. As penetration increases, pressure increases dramatic: at 3 meters, blast pressure increases approximately 33%; at 6 meters, 80%. Previous penetration categories extending 6 and 15 meters (20 and 50 feet) exceed realistic allowance at most sites. Therefore, acceptable penetration of the cargo bed is now limited to one meter or less.

4. Terminology

4.1. *Perimeter barrier*: A gate, bollard, wall, fence, planter, other structure, or natural topographic feature which provides protection against vehicle entrance to the compound. The perimeter is typically the outermost area over which the post has control and is normally defined by the property line.

4.2. *Bollard*: Vertical barrier, usually steel, concrete, or combination of steel and concrete, used to channel or restrict vehicular traffic.

4.3. *Setback (standoff)*: Distance from the inside edge of a barrier to the nearest surface of the building being protected.

4.4. *Penetration distance*: Distance from the pre-impact, inside edge of a barrier to the leading edge of the vehicle cargo bed.

4.5. *Pass/fail standard*: To pass, the front edge of the vehicle cargo bed must not penetrate more than one meter from the pre-impact, inside edge of a barrier. Penetration greater than one meter fails.

4.6. *Rated anti-ram barrier*: A DS-approved perimeter barrier that does not exceed the defined penetration level for a 6,800 kg (15,000 lb) gross weight vehicle traveling perpendicular to the barrier at nominal speeds of 80 kph (50 mph), 65 kph (40 mph), or 50 kph (30 mph).

5. Summary of Test Method

5.1. A set of drawings and specifications for a proposed barrier or gate must be submitted to DS/PSP/PSD for review. Upon modification, if required, and acceptance by DS, the proposed barrier or gate is scheduled, in coordination with a DS technical representative, for evaluation at a DS-approved facility. DS reserves the right to have a representative present to witness all testing. Test article construction and test preparations are made in accordance with this Standard.

5.2. One of three nominal impact speeds is chosen by the vendor for rating certification. Following pre-test documentation, the test is conducted at the chosen speed, using a test vehicle and ballast conforming to specifications. Dynamic test data is recorded using the approved methods.

5.3. If impact conditions are within acceptable limits for a valid test, barrier performance is documented and a pass/fail rating is recommended. Following DS approval, acceptable barriers are added to the DOS-certified list with the DS-approved rating.

6. Significance and Use

6.1. DOS diplomatic facilities use "vehicle impact-rated barriers" from DOS-certified lists for perimeter protection worldwide.

6.3. When dynamic testing is required, DS test procedures in this Standard permit performance evaluation of a perimeter barrier or gate to certify its level of protection against vehicle attack.

6.2. The authority to determine the appropriateness of using technical analyses or computer modeling in lieu of dynamic testing for new designs and design changes lies solely with DS/PSP/PSD.

7. Test Criteria

7.1. *Impact performance*

7.1.1. The level of impact kinetic energy a barrier is proposed to withstand must first be established. This level is then compared with the kinetic energy levels shown in Table 1 to determine

the desired test impact speed. Actual test speed must be within the permissible speed range to receive the condition designation. The amount of vehicle cargo bed penetration of the test article at impact speed determines whether the test article receives a pass or fail rating at that condition designation.

Table 1. Impact condition designations for a gross vehicle weight (GVW) of 6,800 kg (15,000 lbs)

Nominal impact speed	Permissible impact speed range	Kinetic energy	Desig-nation
80 kph *50 mph*	75.0-above kph *47.0-56.9 mph*	1,695,000 J *1,250,000 ft-lb*	K12
65 kph *40 mph*	60.1-75.0 kph *38.0-46.9 mph*	1,085,000 J *800,000 ft-lb*	K8
50 kph *30 mph*	45.0-60.0 kph *28.0-37.9 mph*	610,000 J *450,000 ft-lb*	K4

7.2. *Test site*

7.2.1. Tests must be at DOS-approved test facilities. These facilities have adequate space to accelerate test vehicles to the desired impact velocity; level, unobstructed impact regions; and no curbs, dikes, or ditches in front of the installation except where test conditions specify such features.

7.2.2. For test articles embedded in soil, including concrete footings, the soil should be low-cohesive, well-graded crushed stone or broken gravel of a particle size distribution comparable to Table 2. Soil depth should be at least the foundation depth and 1.5 times embedment depth behind the installation or 0.6 meters (2 feet), whichever is greater up to a maximum of 6 feet. Soil should be compacted to a density of not less than 90 percent maximum dry density.

Table 2. Recommended soil foundation material

Sieve Size	Mass Percent Passing
50.0 mm (2 in.)	100
25.0 mm (1 in.)	75-95
9.5 mm (3/8 in.)	40-75
4.75 mm (No. 4)	30-60
2.00 mm (No. 10)	20-45
0.425 mm (No. 40)	15-30
0.075 mm (No. 200)	5-20

7.3. *Test article*

7.3.1. Test article materials and construction drawings must be provided to DS for review a minimum of 14 days in advance. The barrier shall then be constructed and erected in a manner representative of the proposed actual service installation and conform to manufacturer or designer specifications and drawings. Deviations from fabrication, specification, or erection details must be delineated in the test report.

7.4. *Test vehicle*

7.4.1. The test vehicle shall be a medium duty truck with diesel engine, tested at a gross vehicle weight of 6,800 kg (15,000 lbs), ± 90 kg (200 lbs). U.S. medium duty trucks, which have gross vehicle weight typically ranging from 6,350 kg (14,001 lbs) to 11,800 kg (26,000 lbs).

7.4.2. Illustrative U.S. manufactured medium duty trucks are shown in Table 3.

Table 3. Typical U.S. medium duty trucks

Make	Model	GVW
Ford	F650	8,846 – 11,800 kg *19,501 – 26,000 lbs*
Ford	F700	11,113 – 13,835 kg *24,500 – 30,500 lbs*
Chevrolet	C6500	9,525 – 11,800 kg *21,001 – 26,000 lbs*
Freightliner	FL60	8,165 – 12,020 kg *18,000 – 26,500 lbs*
International	4700 DT466E	6,125 – 11,800 kg *13,500 – 26,000 lbs*
International	1652	9,750 – 12,700 kg *21,500 – 28,000 lbs*

7.4.3. Table 3 is not all-inclusive; comparable vehicles may be acceptable as a test vehicle. A description of the proposed test vehicle, whether from Table 3 or an alternative vehicle must be submitted to DS for review along with the drawings and specifications of the test article. Early coordination is encouraged, especially regarding acceptability of the proposed test vehicle.

7.4.4. The essential features for test vehicle selection are that it:

7.4.4.1. Be "medium duty".

7.4.4.2. Have a diesel engine.

7.4.4.3. Be structurally sound (no major rust or structural weakness).

7.4.4.4. Have a standard, commercial bed.

7.4.4.5. Have an unmodified bumper.

7.4.4.6. Not have any structural additions or modifications which may enhance test performance.

7.4.5. Ballast attachment has been revised to provide greater realism, and consistency in performance evaluation. Ballast material will no longer be dense materials such as steel or concrete,

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firmly anchored or welded to the truck rails; ballast shall be sand- or soil-filled, 208 liter (55-gallon) steel drums securely attached to the vehicle cargo bed, as described in Section 9.

8. Apparatus (data acquisition methods)

8.1. Appendices A and B describe parameters to be measured before, during, and after collision, including measurement tolerances and techniques.

8.2. Pre-test data acquisition shall document the as built, untested barrier and test vehicle configuration. Documentation includes as-tested specifications and drawings, measurements and photography.

8.3. During the test, vehicle impact speed and impact point must be measured. Video documentation, with perpendicular (profile), overhead, and oblique views, are also to be made.

8.4 Vehicle acceleration is to be measured near center of mass. Kinematics, barrier displacements, and strains may be important when a barrier needs modification or redesign; this data may be collected during testing, at the option of the client.

8.5. After the test, barrier deformation, vehicle penetration depth, and damage of both test article and vehicle shall be documented with measurements, data recordings, and photography. Other parameters peculiar to a barrier may entail additional documentation. For instance, a gate may be shown to be operational after the collision, even though this is not a requirement of this standard.

9. Test Preparation

9.1. *Test article*

9.1.1. Each device, assembly, or structure used in a barrier is to be identified and documented by engineering drawings and specifications.

9.1.1.1 All proprietary information shall be clearly indicated in the document. *All such information provided to State Department personnel will be safeguarded and will not be disclosed to unauthorized personnel.*

9.1.1.2 Each sheet shall include the barrier title/description, drawing number, and date and shall be submitted in 8½"x11" (215x280mm) format. Each drawing shall identify the barrier in exact detail. Assembly drawings shall show the arrangement, locations, and dimensions of all components.

9.1.1.3 Specifications for materials used, location and type of all welds, and size and spacing of all rebar, shall be included in the documents.

9.1.2. Standard commercial materials used in construction will conform to configuration and performance standards established for the material by appropriate industrial specifications, e.g., American Society of Testing Material, American Iron and Steel Institute, Society of Automotive Engineers, or manufacturer's assembly specifications.

9.1.3. Non-standard materials or devices used in configurations not otherwise controlled by recognized industrial or manufacturer specifications will be accompanied by full disclosure drawings and specifications.

9.2. *Test article installation*

9.2.1. For gates, adjacent structures used to support the gate and resist induced forces during the crash test must be specified and documented.

9.2.2. The length of a barrier test article, excluding terminals and anchors, shall be at least three times the width in which deformation is predicted, but not less than 6 meters (20 feet). These include walls, fences, and bollards.

9.2.3. A freestanding barrier, such as a portable concrete barrier or planter, which depends on frictional resistance between it and the ground to resist movement, shall be tested on the same general type of ground or pavement surface where it will be used. The type of pavement surface, as well as end anchorage used, shall be reported.

9.2.4. Other test articles or vehicle arrest devices such as pits may be evaluated by this test standard provided they have adequate descriptions, drawings, and specifications.

9.3. *Test vehicle*

9.3.1. The test vehicle will be configured with an open flat bed and unmodified commercial bumper. Gross weight of the test vehicle shall be 6,800 kg (15,000 lbs), ± 90 kg (200 lbs). All necessary ballast (cargo) to bring the vehicle to test mass shall be **firmly** attached to the cargo bed of the vehicle and visible for performance assessment during impact.

9.3.2. Attachment must ensure that the cargo remains intact upon impact until it has transferred its kinetic energy to the impact process. Ballast will be standard, round, "open top" (removable top, secured with ring and nut/bolt, or level-lock mechanism), 208 liter (55-gallon), metal drums filled with sand or soil. 208 liter drums are typically 610 mm (24 inches) in diameter and 883 mm (34 ¾ inches) outside height. (ISO "containerizable" steel drums may also be used. These are 595 mm (23 7/16 inches) with the same inside diameter as the standard 55-gallon drum.) Photos of a typical test vehicle configuration and ballast attachment using 10,000 pound capacity cargo straps are shown in Figures 1 and 2.

9.3.3. A test vehicle drawing is in Appendix B, showing dimensions and properties to be

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measured and recorded prior to testing. Similar attachment techniques that firmly secure the cargo may be proposed, but such variations must be submitted pre-test to the DS technical representative for review.

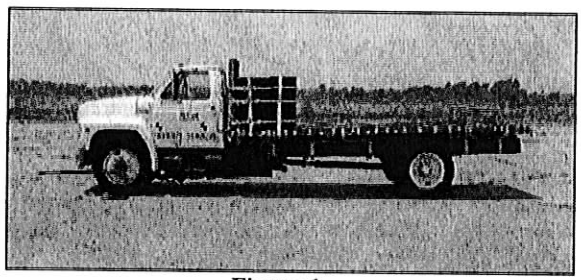

Figure 1.
Typical test vehicle configuration, side view

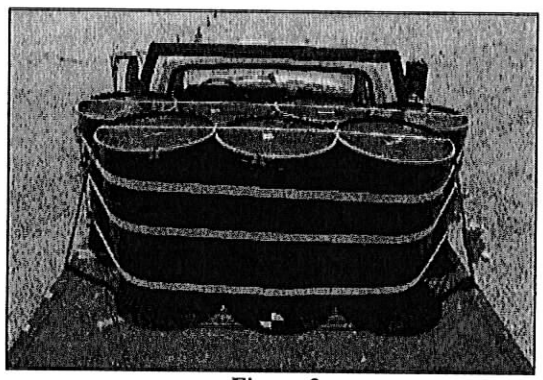

Figure 2.
Typical ballast attachment, rear view

10. Test Procedure

10.1. *Compliance*

10.1.1. DS reserves the right to have a representative present to witness all testing and requires a minimum of 14 days advance notice from the Facility Test Director for this purpose.

10.1.2. Once a test article is committed to testing for the purpose of obtaining an official DS rating, a report of all testing conducted on the device or assembly is to be provided to DS regardless of the outcome. Test documentation indicating compliance with the vehicle impact resistance requirements and test results will be submitted to DS/PSP/PSD by the testing facility.

10.2. *Pre-test submissions*

10.2.1. The contractor will provide a test plan consisting of drawings and specifications of the device, assembly or structure to be tested, configuration disclosure documentation, description of the proposed test vehicle, and proposed impact conditions to the DS technical representative at least 14 days in advance of testing.

10.3. *Impact conditions*

10.3.1. The method of vehicle guidance prior to impact is optional, providing the guidance system or its components do not effect significant changes in the vehicle dynamics during and immediately after collision. The test vehicle may be pushed, towed, or self-powered to the programmed speed. If pushed or towed, the prime mover shall be disengaged prior to impact.

10.3.2. The test vehicle shall approach and impact the test article at 90 degrees, ±3 degrees. Vehicle impact shall be centered on the most vulnerable section or part of the test article. The DS technical representative must review the proposed impact point prior to the test. Actual impact point shall be within ± 300 mm (1 foot) of this target.

10.3.3. Actual vehicle impact speed must be within the permissible range shown in Table 1 to receive the designated condition level at the intended nominal speed. Tests with vehicle impact speed outside this range are not valid for the rating assignment, but may be rated by DS at the appropriate lower speed category.

10.4. *Evaluation of performance level*

10.4.1. For new construction and existing facilities, ultimate dynamic performance objectives severely limit permissible penetration ***Revision A requires measurement of the extent to which the front edge of the test vehicle cargo bed penetrates or vaults over the system.***

10.4.2. ***The new DS performance criteria limits penetration of the front edge of the cargo bed to one meter beyond the pre-impact, inside edge of the barrier.*** Cargo bed penetration even may be negative if the leading edge does not reach the barrier.

10.5. *Rating assignment and certification*

10.5.1. If the front edge of the cargo bed does not penetrate greater than one meter beyond the pre-impact, inside edge of the barrier, a pass rating is assigned at the appropriate speed designation, K12 (80 kph), K8 (65 kph), or K4 (50 kph), from Table 1.

11. Test Report

11.1. The Test Report, prepared by the DS-approved testing facility, shall include, but not be limited to, the following sections:

11.1.1. *Identification*: Name, address, and contact data of testing organization, responsible personnel, test facility location, and test date.

11.1.2. *Barrier description*: Describe as-built test article, including photographs, engineering drawings, material specifications, and reference to

design revisions from any earlier tests. Describe special fabrication and installation procedures (such as heat treatment, weldments, bolt tension, galvanizing in critical stressed areas, etc.) that may influence dynamic behavior. Include drawings and specifications for recommended design changes.

11.1.3. *Test vehicle description:* Describe vehicle (make, model, year, engine type, tire size, test weight, condition, bed and ballast configuration). Provide measurements in the format at Appendix B.

11.1.4 *Test procedure*: Describe test facility and associated equipment, data acquisition systems, and procedures used in calibrating and processing data. Include soil properties and other conditions applicable to barrier performance.

11.1.5. *Findings*: Use format shown in Table 4. Include video with before-and-after documentary coverage of test article and vehicle, high-speed data views of the impact (overhead, perpendicular (profile), and oblique), and title block for each identifying test and test conditions.

11.1.6. *Evaluation*: Discuss dynamic performance of test article (structural adequacy, vehicle trajectory, penetration). Provide conclusions regarding acceptability of dynamic performance and recommend rating.

12. Retest and Design Modifications

12.1. *Re-testing*

12.1.1. Failure of any assembly or device to demonstrate full compliance with the requirements of this Standard does not preclude the modification and resubmission of that assembly design for re-testing. Any re-testing will be conducted in accordance with all requirements in this Standard.

12.2. *Design modifications*

12.2.1. All modified material accepted by DS shall bear an addendum to the model number which clearly identifies it as a revised configuration differing from previous modifications.

12.2.2. Once satisfactory vehicle impact resistance has been demonstrated and a barrier rating assigned, no design or material change may be made without prior approval of the DS, which may require complete or partial re-testing.

13. Keywords

14.1. anti-ram; perimeter; crash testing; barriers; gates; bollards; walls; fences; planters

Table 4. Report Format

Item	Description	Format
Still photography	Vehicle and barrier installation, before and after test	Photographs (jpeg, tiff, or bitmap)
Movie during test	Sequence (4-8 frames minimum) during impact (overhead, side, and oblique)	Video (VHS)/CD/ photographs
Vehicle acceleration	Lateral and longitudinal; filtered (SAE J211, Class 180)	Plots (ordinate 50g; Abscissa 300ms) (Dplot or ascii)
Dynamic strain	Strain gage data from critical barrier/gate points	Plots (ordinate 500 μ in/in; Abscissa 100 ms) (Dplot or ascii)
Strain gages	Drawing showing strain gage locations	Drawing (pdf or MS Word)
Permanent deformation	Profile of deformation	Table (Excel)
Dynamic deformation	Maximum deformation of test article	Text (MS Word)
Damage estimate	Barrier length, elements or components required to restore installation	Text, drawings, and/or photos (same formats as above)

Appendix A. Data acquisition methods

Phase	Parameter	Measurement Tolerances	Acceptable Techniques	Remarks
Pretest	Test article installation	± 6 mm (± 1/4 in)	General surveying equipment, photography	Post spacing, rail heights, alignment, orientation, etc., are critical items
	Mass of vehicle and onboard elements	±2% of items but not more than ± 90 kg (± 200 lb)	Commercial scales	Mass distribution of vehicle as tested.
	Geometry of vehicle	± 6 mm (± 1/4 in)	Common scales	See Appendix B for critical items
Test	Impact speed	± 0.32 kph (± 0.2 mph)	(a) Contact switches (b) High-speed cine (c) Radar (d) Fifth wheel	Minimum film speed of 120 mps (400 fps) Speed measured during vehicle approach at a maximum 4.6 m (15 ft) from point of impact
	Vehicle accelerations	±1g	(a) Accelerometers designed for high-"g" service	Lateral and longitudinal (and preferably vertical) accelerometers attached to a common mounting block and the block attached to the vehicle structure on vehicle centerline at center of vehicle gross weight distribution (longitudinal). A second set of accelerometers is a desirable option. Complete data system responsive to 0-min. 500 Hz signal. Raw data recorded and maintained as permanent record. Data may be filtered for visual presentation.
			(b) High-speed cameras (To be used only as a backup or secondary system due to uncertainty in data processing attributed to a double differentiation calculation)	Minimum film speed of 120 mps (400 fps). Internal or external timing device: stationary references located in field of view of at least two cameras positioned 90 degrees apart. Layout and coordinates of references, camera positions, and impact point should be reported. Two vehicle references are to be located on the vehicle roof, one positioned directly above the vehicle center of mass and the second 1.5 m (5 ft) to the rear. Instant of impact should be denoted by a flash unit placed in view of data camera. The instant of impact should also be recorded on magnetic tape.
	Vehicle trajectory, and roll, pitch and yaw	± 0.3 m (± 1.0 ft) ±0.5 deg	High-speed cameras	Minimum film speed of 60 mps (200 fps). Overhead and end views of installation preferred.
	Test article dynamic deformation.	± 24 mm (1 in)	High-speed cameras	Overhead camera view; minimum film speed of 60 mps (200 fps)
Post test	Test article permanent deformation/final position.	6 mm (1/4 in)	General surveying equipment	Location of significant debris reported.
	Test article/vehicle damage/final position.	(not applicable)	Visual inspection	Standard photographs should be shown in report.