

Tractor-trailer Reverse Movement Path

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The design of commercial and industrial facilities to accommodate tractor-trailer deliveries often requires the provision of an area for reverse movements. A review of recent literature revealed that the tractor-trailer turning templates available are intended for forward movements; the most often referenced templates are presented in *A Policy on the Design of Highways and Streets*, American Association of State Highway and Transportation Officials (AASHTO), 1990.' The variables that affect the turning path of a reversing tractor-trailer are significantly different than those for a forward-moving tractor-trailer. The project described in this article investigated these variables and developed a template for the reverse movement of a tractor-trailer at a loading facility.

Identification of Design Elements

The field tests performed for this research identified several of the important variables involved with reverse movements of tractor-trailers at a loading facility. The following discusses several of the vehicle and site variables to be considered in determining the area required for tractor-trailing loading maneuvers.

Truck Dimensions

The vehicle tested in this research has the dimensions indicated in Figure 1 and is classified as a WB-50 (AASHTO). This vehicle was chosen because it is very common and provides an estimate of other similar vehicles. Tractor-trailer combinations consisting of a single trailer of different lengths and/or wheelbases are expected to operate in a similar manner, but with different dimensions in the turning path.

Tractor Types

There are three predominant types of tractors in use: conventional, cab-over and yard. The conventional type consists of a frame with the driver seated behind and above the engine. The cab-over tractor generally has a shorter wheelbase and positions the driver above and somewhat in front of the engine. The yard tractor is specifically designed for moving trailers to dock positions once they have been delivered to a trailer facility. This type of vehicle is specially equipped to allow trailers to be maneuvered in a much smaller area. A yard tractor is also generally operated by a highly skilled driver. A conventional tractor was used in these tests and for the development of the template.

Location of the Fifth Wheel

The fifth wheel is the pivot point and mechanical connection between the tractor and trailer. This circular plate is spring-loaded in the horizontal plane to deflect as it is pushed against by the trailer's kingpin; it then locks the kingpin into place. Once locked into place, the kingpin allows the trailer to rotate about the center of the fifth wheel, which is set on the tractor frame and can be locked into place at several locations along the frame. The location of the fifth wheel at the front of the tractor is limited by the distance required for the front of the trailer to rotate without interfering with the cab. At the rear of the tractor, the location is limited by the length of the frame. The vehicle used for the test had its fifth wheel located 6 feet (ft) from the rear of the tractor.

Location of Trailer Rear Axle

The rear axle configuration of the trailer used in the tests is typical of most trailers and consists of two axles, each with four wheels. Each axle has a differential mechanism that allows the wheels on the outside of a turn to rotate a greater distance than the wheels on the inside. This avoids a skipping or jumping motion associated with a fixed axle. The particular axle configuration on the test trailer is constructed as a unit and mounts to the trailer along an adjustable rail. The position of this axle group varies along the rear of the trailer, depending on the trailer manufacturer and the selected position. In general, the closer the axle configuration is placed to the front of the trailer, the smaller the path required for the trailer to maneuver. The test trailer had the center of the rear wheel of the axle configuration mounted 7.1 ft from the rear of the trailer.

Steering Mechanism

One assumption generally made in the determination of tractor-trailer turning paths is that the tractor's turning radius can be changed instantly from one extreme to another. This assumption may be valid for vehicles equipped with power steering, but is less accurate for low-speed movement of vehicles without power steering. This analysis includes a 3-ft arc at an 80-ft radius to describe the path of the tractor-trailer during the period of wheel movement. The tractor used in the field was not equipped with power steering. This is generally the case for over-the-road fleet equipment. Many privately owned tractors, tractors used for inner-city delivery routes and most yard tractors are equipped with power steering.

Truck Approach Path

The test was developed with the intention of determining a path whose difficulty would not create an inefficient process in delivering the trailer to the dock. The combination of three forward and reverse movements was selected to describe operation. The purpose of this study is to develop criteria for truck loading facilities that are reasonable for both small and large facilities and for drivers of all experience levels.

Trailer Docking Position

Another variable in the determination of the required area for truck maneuvers is the location of the dock and surrounding obstructions. The most limiting situation at a multiple dock location occurs when a trailer is delivered between two trailers that are standing at adjacent positions. For the purpose of this analysis the situation where the desired dock has a 48-ft trailer parked on either side was chosen.

Description of the Test Vehicle

The test vehicle is a typical WB-50 design vehicle. Of particular concern for the test vehicle are the tractor type, location of the fifth wheel, and location of the rear axle group. The tractor is of the conventional style as opposed to a cab-over style. The policy of many trucking firms require that the fifth wheel be located as indicated in Figure 1, as the pivot point between tractor and trailer can be positioned at several settings, either closer to or farther from the cab. Similarly, the trailer's rear axle group can be located either farther forward or to the rear. The position indicated is the standard set by many companies for over-the-road shipments. In certain regions of the country and for local delivery trailers, the trailer axles are set at the most forward position to increase maneuverability.

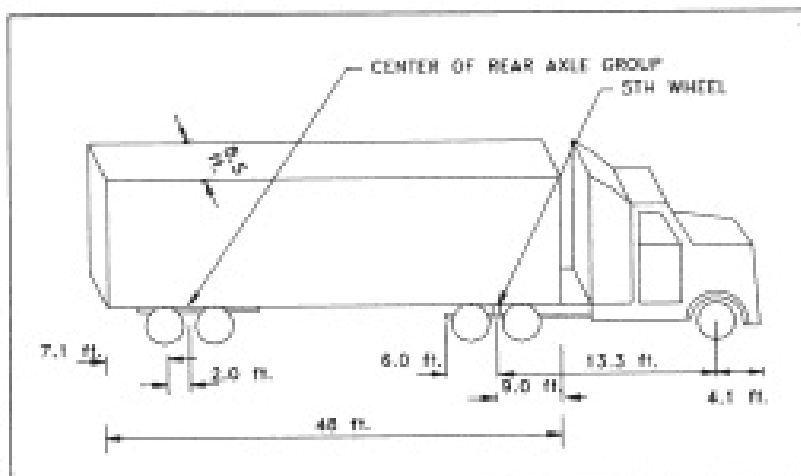


Figure 1. Dimensions of the test vehicle

Description and Results of Physical Tests

The field tests consisted of moving a tractor-trailer to a loading dock position that had 48-ft trailers stored in the adjacent dock positions. The driver was instructed to approach parallel to the dock and to use only three reverse/forward movements to deliver the trailer to the dock. The three movement criteria were selected to describe a movement path that would provide efficient terminal operation.

The tractor-trailer moved past the dock. The driver then reversed in a path that involved turning the tractor steering at its minimum radius until the trailer rear axle group began to twist. Next, the driver moved forward to align the tractor and trailer. The reverse movement was then repeated to the angle where twisting occurred. The

driver then moved forward, and a final reverse movement aligned the trailer at the loading dock. Figure 2 indicates the maneuvers involved. The dashed lines indicate the AASHTO forward movement path for the vehicle exiting from the dock position.

Test Results

Test results are indicated in Figure 3. The tests indicate the minimum area necessary for efficient docking. This minimum is a subjective parameter and is based on the driver's effort and time (number of forward and backward movements) required to place the trailer into position. The movements in the field tests used the point at which resistance to motion (twisting) was sensed as a limiting point.

Identification of Template

Figure 3 also indicates the tractor-trailer template for the study vehicle approaching parallel to the dock and utilizing three reversing movements to deliver the trailer to the dock. The template consists of the outline of the numerous forward and reversing movements. Outlines for the vehicle approaching from both the left and right are not included since these are mirror images. The tractor-trailer approaching from the right is preferred since it allows the driver to observe the rear of the trailer in the mirrors during the backing operations. This template also includes the AASHTO forward movement path for the exiting vehicle.

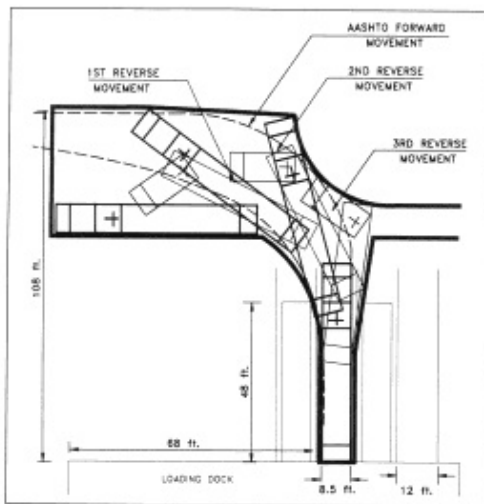


Figure 2. Test results

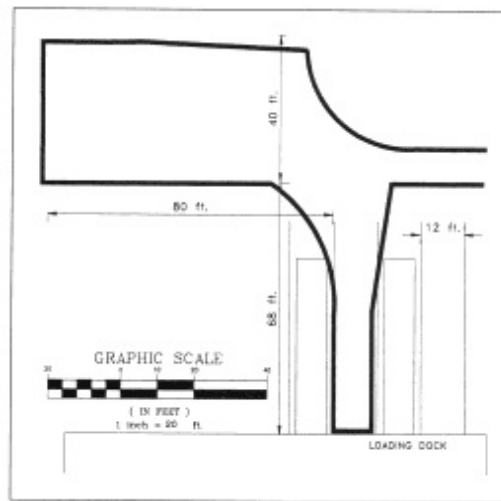


Figure 3. Loading facility template

Testing of Template Against Existing Sites

To determine its applicability, the template in Figure 3 was tested on the plans of three existing facilities in the Lehigh Valley Industrial Park near Bethlehem, Pa. The template indicated quite accurately the area used for loading maneuvers. Two of the site plans indicated that the existing paving area was not sufficient; this was confirmed by observation at the facilities.

Conclusion

The template in Figure 3 provides a reasonable guideline for the planning and design of loading areas for WB-50 tractor-trailers approaching parallel to the dock. The template indicates the minimum area required for the docking operation.

To better determine the requirements of tractor-trailers at loading facilities, additional studies are needed to identify the effect of the following variables.

Vehicle Size

- Variable wheelbase tractors
- Variable wheelbase trailers
- Variable fifth wheel settings on the tractor
- Variable rear axle group settings

Vehicle Approach

- Variable approach angles
- Variable distances from docking area

Driver Variables

- Determination of skill level appropriate for design
- Variations at a site with the same vehicle and different drivers

The development of this template is based on the recording of one set of tests with a single driver at a single site. Additional research is required to determine the variations associated with different drivers and facilities.

References

1. *A Policy on Geometric Design of Highways and Streets*. American Association of State Highway and Transportation Officials, 1990.



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