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StandardTest Method for Vehicle Crash Testing of Perimeter Barriers[1]

This standard is issued under the fixed designation F2656; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Original perimeter barrier test methods were first published in 1985 by the Bureau of Diplomatic Security to assess the crash performance of perimeter barriers and gates. Since that time, the frequency and scale of attacks using vehicles with or without an explosive payload have increased both internationally and domestically. Therefore, there is a need to address a broad spectrum of possible incident conditions such as credible threat vehicle types for the locale, attack velocities of the different vehicles, and different acceptable penetration limitations. Also, there are different evaluation criteria for different agencies that fulfill their unique access control operations, aesthetics, and other organizational requirements. This test method is intended to expand the current Department of State, Bureau of Diplomatic Security's crash testing standard to meet the broader needs of multiple organizations responsible for the protection of U.S. assets domestically and abroad.

Published test standards for perimeter security devices have previously been maintained by the U.S. State Department, Bureau of Diplomatic Security. The Specification for Vehicle Crash Test of Perimeter Barriers and Gates was first published in 1985 as SD-STD-02.01. In that standard, the test vehicle was specified as a medium-duty truck weighing 6800 kg (15 000 lb). The payload was to be securely attached to the frame and nominal impact velocities were 50 km/h (30 mph), 65 km/h (40 mph), and 80 km/h (50 mph). Penetration limits were 1 m (3 ft), 6 m (20 ft), and 15 m (50 ft) and were measured from the attack face of the perimeter security device to the final resting position of the front of the frame rails of the test vehicle.

In 2003, the U.S. State Department, Bureau of Diplomatic Security issued an updated standard (SD-STD-02.01, Revision A) for the testing of perimeter barriers. This update was done for several reasons. The foremost reason for change was limited setback distances precluded the use of any devices at their facilities or compounds that did not meet the highest test level, that is, those allowing more than 1-m (3-ft) penetration distance. Therefore, the revised standard only uses a 1-m (3-ft) penetration distance. Secondly, the method of rigid attachment of the ballast to the test vehicle was not simulating likely payload configurations and was altering the structural integrity of the test vehicle. Consequently, the updated standard requires a payload consisting of 208-L (55-gal) steel drums strapped together that have been filled with soil. This assembly is then strapped to the vehicle load platform. The third reason for change was based on the observation that the cargo bed of trucks could effectively penetrate certain types of barriers. Accordingly, the penetration distance is now measured from the inside face or non-impact surface of the barrier to the front of the cargo bed when the vehicle has reached its final position. Lastly, it was determined that the trucks used different platforms within a given class affecting result consistency. The revised test standard now requires the use of very specific diesel-powered medium-duty trucks.

1. Scope

1.1 This test method provides a range of vehicle impact conditions, designations, and penetration performance levels. This will allow an agency to select passive perimeter barriers and active entry point barriers appropriate for use at facilities with a defined moving vehicle threat. Agencies may adopt and specify those condition designations and performance levels in this test method that satisfy their specific needs. Agencies may also assign certification ratings for active and passive perimeter barriers based on the tests and test methodologies described herein. Many test parameters are standardized to arrive at a

[1] This test method is under the jurisdiction of ASTM Committee F12 on Security Systems and Equipment and is the direct responsibility of Subcommittee F12.10 on Systems Products and Services.

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common vehicle type and mass, enhance test realism and replication, and produce uniform rating designations.

1.2 Compliance with these test procedures establishes a measure of performance but does not render any perimeter barrier invulnerable to vehicle penetration. Caution should be exercised in interpreting test findings and in extrapolating results to other than test conditions. While computer simulations are powerful tools that are useful in the development of new and improved barriers or in estimating performance under differing conditions, use of only the results from computer simulation for fielding a product is strongly discouraged. When performing a test, developers and users are encouraged to address specific or unusual site conditions as needed. Often local terrain features, soil conditions, climate, or other items will dictate special needs at specific locations. Therefore, if site conditions are likely to degrade a barrier's performance, the agency in need of a perimeter barrier should require testing with the specific site conditions replicated for full-scale crash testing.

1.3 Product/design certification under this test method 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.

1.4 The values in SI units are to be regarded as the standard. The values shown in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth) (Withdrawn 2007)[3]

2.2 *AASHTO Standards* [4]

M147-65 Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Table 1 Grading Requirements for Soil-Aggregate Materials, Grading B

T099 Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop

2.3 *ISO Standard* [5]

ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories

2.4 *SAE Standard* [6]

J211-1 Instrumentation for Impact Test – Part 1: Electronic Instrumentation

J211-2 Instrumentation for Impact Test – Part 2: Photographic Instrumentation

2.5 *U.S. Army Corps of Engineers – PDC Standard* [7]

DOD Certified Anti-Ram Vehicle Barriers[8]

2.6 *U.S. Department of State – DS* [9]

SD-STD-02.01 Specification for Vehicle Crash Test of Perimeter Barriers and Gates, 1985

SD-STD-02.01, Revision A Test Method for Vehicle Crash Testing of Perimeter Barriers and Gates, 2003

3. Terminology

3.1 *Definitions:*

3.1.1 *"A" pillar, n*—structural member forming the forward corner of the cab or passenger compartment.

3.1.2 *accredited independent testing laboratory, n*—testing laboratory accredited to perform the referenced testing procedures by a nationally recognized accrediting agency in accordance with ISO/IEC 17025 and led by a test director.

3.1.2.1 *Discussion*—Accredited independent testing laboratories may have no financial interest in or otherwise be affiliated with companies or individuals for which they perform accreditation testing. Hereinafter, accredited independent testing laboratories are referred to as either accredited facilities or testing laboratories. Other independent testing agencies actively pursuing accreditation and whose testing protocols are accepted by a federal agency may also conduct tests for a period of one year after performing the first test using this test method.

3.1.3 *agency, n*—specifier, responsible party, or owner.

3.1.4 *berm, n*—mounded section of available material such as soil, gravel, rock, and so forth.

3.1.5 *bollard, n*—vertical posts or series of posts, usually steel, concrete, wood, or combinations of same, used to channel or restrict vehicular traffic which includes fixed, removable, and operable/retractable posts.

3.1.6 *condition designation, n*—relates vehicle type and vehicle velocity to the kinetic energy for which testing is conducted.

3.1.7 *continuous barrier, n*—any perimeter barrier that relies on a continuous foundation or a continuous structural element to resist penetration by vehicles.

3.1.8 *debris, n*—post-impact barrier and vehicle components disbursed due to impact.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

[5] Available from International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[6] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

[7] Available from the U.S. Army Corps of Engineers, Protective Design Center, 12565 W. Center Rd., Omaha, NE 68144-3869, https://pdc.usace.army.mil/library/BarrierCertification. Maintains 1985 list for penetration purposes.

[8] These barriers meet the certification criteria of SD-STD-02.01, Revision A, dated March 2003, with the exception of penetration, which has been evaluated for conformance with SD-STD-02.01, April 1985 (the previous version of the DOS testing criteria).

[9] Available from U.S. Department of State, Bureau of Diplomatic Security, Office of Physical Security Programs, Physical Security Division, Washington, D.C. 20520-1403

3.1.9 *ditch, n*—excavation into existing grade with varying cross sections such as "V" or "U" shaped.

3.1.10 *dynamic penetration distance, n*—during the crash event, the maximum horizontal penetration distance of the reference point on the test vehicle, as defined in 7.5.2, to the pretest location of a reference point on or near the perimeter barrier.

3.1.10.1 *Discussion*—See Annex A1 for barrier reference point locations.

3.1.11 *final resting point, n*—distance from the pre-impact reference point on a perimeter barrier to the defined vehicle reference point at final rest.

3.1.12 *override, n*—a type of crash in which a portion of a vehicle goes over a barrier.

3.1.13 *penetration rating, n*—rating achieved by a barrier based on dynamic penetration distance for a given condition designation.

3.1.14 *perimeter barrier, n*—gate, bollard, wall, fence, planter, other structure, or natural topographic feature (that is, berms, rocks, or trenches) that provides protection against a vehicle trying to overtly gain access to a compound or facility.

3.1.14.1 *Discussion*—Active barriers will operate to allow traffic to flow while passive barriers are not easily moved. The perimeter is typically the outermost boundary over which the facility has control and is normally defined by the property line.

3.1.15 *rated-ASTM perimeter barrier, n*—tested perimeter barrier that achieves a given penetration rating based on a defined test vehicle traveling perpendicular to the barrier at a specified impact velocity.

3.1.16 *setback, n*—horizontal distance from the barrier reference point to the nearest surface of the building being protected.

3.1.16.1 *Discussion*—Loss of setback is equivalent to the original setback minus the penetration distance as defined by 7.5.2 for the respective vehicles.

3.1.17 *supplier, n*—manufacturer, distributor, designer, or constructor of the barrier system that is to be tested and can include contractors, engineers, and architects.

3.1.18 *test director, n*—employee of the testing laboratory responsible for all aspects of a test.

3.1.19 *test vehicle, n*—designated vehicle for specific crash testing.

3.1.20 *underride, v*—a type of crash in which a portion of a vehicle goes under a barrier.

3.2 *Acronyms:*

3.2.1 *AASHTO*—American Association of State Highway Transportation Officials

3.2.2 *DHS*—U.S. Department of Homeland Security

3.2.3 *DOD*—U.S. Department of Defense

3.2.4 *DOE*—U.S. Department of Energy

3.2.5 *DOS*—U.S. Department of State

3.2.6 *DOS-DS*—Department of State-Bureau of Diplomatic Security

3.2.7 *DOT*—U.S. Department of Transportation

3.2.8 *GSA*—General Services Administration

3.2.9 *ISO*—International Standards Organization

3.2.10 *NCHRP*—National Cooperative Highway Research Program

3.2.11 *OBO*—Overseas Building Operations

3.2.12 *USACE-PDC*—United States Army Corps of Engineers-Protective Design Center

3.3 *Abbreviations:*

3.3.1 *fps*—frames per second

3.3.2 *ft/s*—feet per second

3.3.3 *g*—measure of acceleration referenced to gravity

3.3.4 *km/h*—kilometers per hour

3.3.5 *lbm*—pounds mass

3.3.6 *m/s*—meters per second

3.3.7 *mph*—miles per hour

4. Summary of Test Method

4.1 The set of drawings and specifications for a barrier that is to be tested shall be submitted by the supplier to the testing laboratory at least 14 days before testing. These documents shall become part of the permanent test record. If a supplier desires to obtain listing of their barrier by one of several agencies that maintain such lists, then see Appendix X3 for additional information.

4.2 Before testing, an approved test vehicle, test velocity, and desired penetration rating is selected by the supplier in coordination with the test director and others who might be involved. The test is then conducted at the chosen velocity using the defined test vehicle and ballast conforming to this test method. Required test data shall be captured and reported.

4.3 The test director shall determine the validity of the test and, if found valid, shall assign a penetration rating for the barrier. The perimeter barrier shall then become a rated ASTM perimeter barrier

5. Significance and Use

5.1 This test method provides a structured procedure to establish a penetration rating for perimeter barriers subjected to a vehicle impact. Knowing the penetration rating provides the ability to select an appropriate barrier for site-specific conditions around a facility.

5.2 The barrier penetration rating does not imply that a barrier will perform as rated in all site conditions, approach routes, and topography. Also, only single-specimen tests at a specified impact location are required by this test method, and therefore, not all points of impact can be tested and validated for the penetration rating. Other impact locations may respond differently.

6. Apparatus

6.1 Appendix X1 provides recommendations on methods of data acquisition that are required by this test method and Appendix X2 provides example forms that may be used for

TABLE 1 Impact Condition Designations

Test Vehicle/Minimum Test Inertial Vehicle, kg (lbm)	Nominal Minimum Test Velocity, km/h (mph)	Permissible Speed Range, km/h (mph)	Kinetic Energy, KJ (ft-kips)	Condition Designation
Small passenger car (C) 1100 (2430)	65 (40)	60.1-75.0 (38.0-46.9)	179 (131)	C40
	80 (50)	75.1-90.0 (47.0-56.9)	271 (205)	C50
	100 (60)	90.1- above (57.0-above)	424 (295)	C60
Pickup truck (P) 2300 (5070)	65 (40)	60.1-75.0 (38.0-46.9)	375 (273)	PU40
	80 (50)	75.1-90.0 (47.0-56.9)	568 (426)	PU50
	100 (60)	90.1- above (57.0-above)	887 (613)	PU60
Medium-duty truck (M) 6800 (15 000)	50 (30)	45.0-60.0 (28.0-37.9)	656 (451)	M30
	65 (40)	60.1-75.0 (38.0-46.9)	1110 (802)	M40
	80 (50)	75.1-above (47.0-above)	1680 (1250)	M50
Heavy goods vehicle (H) 29 500 (65 000)	50 (30)	45.0-60.0 (28.0-37.9)	2850 (1950)	H30
	65 (40)	60.1-75.0 (38.0-46.9)	4810 (3470)	H40
	80 (50)	75.1-above (47.0-above)	7280 (5430)	H50

parameters to be measured before, during, and after collision, including measurement tolerances and techniques.

6.2 Pretest data acquisition shall document the as-built, untested barrier and test vehicle configuration. Documentation includes as-built specifications and drawings for the test article, measurements, and photography. Survey points for elevation of any base slab, columns, bollards, barrier, or barrier support elements that may define deformation, translation, rotation, and uplift should be recorded in pre- and post-test states.

6.3 During the test, vehicle impact velocity shall be measured. Video documentation, with perpendicular (profile) shall be provided. Overhead and oblique views are recommended. Photographic instrumentation specifications shall be in accordance with SAE Standard J211-2. Minimum high-speed film or video shall be 400 fps or greater. Determination of impact time = 0 s shall be established by the use of a contact ribbon switch mounted to the front face of the barrier or vehicle bumper triggering a strobe flash that can be recorded on the video documentation for cross-referencing between video sources.

6.4 Vehicle acceleration shall be measured. Accelerometer location is shown in Figs. X2.1-X2.4 in Appendix X2. Electronic instrumentation specifications shall be in accordance with SAE Standard J211-1. Some agencies have expressed interest in likelihood of injury to occupants in impacts with unplanned deployments. Therefore, occupant risk values are to be computed per the method of Appendix A in NCHRP Report 350 from the acceleration data.[10]

[10] Ross, H. E., Sicking, D. L., Zimmer, R. A., and Michie, J. D., "Recommended Procedures for the Safety Performance Evaluation of Highway Features," National Cooperative Highway Research Program Report 350, Transportation Research Board, National Research Council, Washington, DC, 1993.

6.5 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. See 6.2 for suggested data collection points. 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 test method.

7. Test Criteria

7.1 *Impact Performance:*

7.1.1 The level of impact kinetic energy that a barrier is to withstand shall be established by the supplier in consultation with the test director and others who might be involved. This level is then compared with the kinetic energy levels shown in Table 1 to select a test vehicle and associated test impact velocity. Actual test velocity shall be within the permissible range indicated to receive the condition designation. During the test, the amount of vehicle penetration of the test barrier at the required impact velocity determines the dynamic penetration rating for the condition designation. Test vehicle dynamic penetration shall be referenced to the base of the "A" pillar on the small passenger car (C), the front leading lower edge of the pickup truck bed (P), the leading lower edge of the cargo bed on the medium duty truck (M), and the leading lower vertical edge of the cargo bed on the heavy goods vehicle (H).

7.1.2 There are four nominal vehicle test velocities in this test method, but only three are associated with each vehicle. These nominal velocities are 50 km/h (30 mph), 65 km/h (40 mph), 80 km/h (50 mph), and 100 km/h (60 mph). The velocity and associated vehicle determine the condition designation (see last column in Table 1).

7.2 *Test Site:*

TABLE 2 Penetration Ratings

Designation	Dynamic Penetration Rating
P1	≤1 m (3.3 ft)
P2	1.01 to 7 m (3.31 to 23.0 ft)
P3	7.01 to 30 m (23.1 to 98.4 ft)
P4	30 m (98 ft) or greater

7.2.1 Tests shall be conducted at an accredited facility. These facilities shall have adequate space to accelerate the test vehicle to the desired impact velocity and have 30 m (98 ft) minimum behind the barrier reference point, as shown in Annex A1, in accordance with Table 2. In general, the space needs to be level with unobstructed impact regions and not contain curbs, dikes, or ditches in front of the test article installation except where test requirements specify such features as part of the barrier system. The surface shall replicate anticipated field deployed conditions.

7.2.2 Unless otherwise required, in test barriers requiring embedment in soil, including concrete footings, the soil shall be low-cohesive, well-graded crushed stone or broken gravel of a particle size distribution comparable to Table 3. The low-cohesive soil shall have a depth equal to the bottom of the foundation and a width equal to 1.5 times the foundation depth behind the test barrier or 0.6 m (2 ft), whichever is greater up to a maximum of 1.8 m (6 ft). The low-cohesive soil shall be either in-situ natural conditions or controlled and compacted fill to a density of not less than 90 % maximum dry density in accordance with Test Methods D1556 and D2922 and AASHTO Method of Test T099. If testing for site-specific soil conditions is being conducted, then testing may be performed in replicated site soil conditions and reported in the test report.

7.2.3 For test barriers that are surface mounted, testing shall be on a surface established by the supplier in consultation with the test director and any others who might be involved. Regardless of the surface on which the barrier is mounted, the profile of the test bed to a depth of 0.6 m (2 ft) shall be determined and documented in the test report.

7.3 *Test Article*—The test barrier shall be constructed and erected in a manner representative of the proposed actual service installation and conform to supplier specifications and drawings. Any deviations from fabrication, specification, or erection details shall be noted in the test report.

7.4 *Test Vehicle*—The test vehicle shall be structurally sound (no major rust or structural weakness), have an unmodified bumper, and not have any structural additions or modifications that may enhance test performance. Tires shall be of the size and type recommended by the manufacturer and inflated to recommended pressure. Note that some agencies have specific vehicle requirements and these shall be complied with when trying to get a tested barrier system onto their listing.

7.4.1 *Small Passenger Car*—The small passenger car shall be manufactured within ten model years of the test date and should be selected based on sales information for the applicable years. The vehicle may be a sedan or coupe configuration. The gross vehicle test mass shall be 1100 ± 20 kg (2430 ± 44 lb). If ballasting is required, water may be added to the fuel tank or weights evenly distributed and securely anchored to the occupant compartment floor. Care should be taken to distribute the ballast uniformly.

7.4.2 *Pickup Truck*—The pickup truck shall be a ¾-ton-rated body style and manufactured within ten model years of the test date and should be selected based on sales information for the applicable years. Two-door, standard cab pickups shall be used. The ¾-ton pickup has been shown to be a good surrogate for the sport utility vehicle. The gross vehicle test mass shall be 2300 ± 50 kg (5070 ± 110 lb). If ballasting is required, care should be taken to distribute the ballast uniformly.

7.4.3 *Medium-Duty Truck*—The medium-duty test vehicle shall be equipped with a diesel engine and tested at a test inertial vehicle mass of 6800 ± 140 kg (15 000 ± 309 lb). U.S. medium-duty trucks have gross vehicle mass ratings typically ranging from 6350 to 11 800 kg (14 000 to 26 000 lb), shall have a wheelbase of 5.28 ± 0.51 m (208 ± 20 in.). A commercially manufactured flat bed, 5.49 ± 0.61 m (18 ft ± 24 in.) long shall be installed per the vehicle manufacturer's specifications. "U" bolts shall be spaced at 1 ± 0.2 m (3 ft ± 8 in.) on center, unless otherwise specified by the vehicle manufacturer and shear plate connections shall be provided on the front and rear of the flat bed as specified by vehicle manufacturer. Ballast material shall be soil-filled, 208-L (55-gal) steel drums attached to the vehicle cargo bed, as described in 7.4.3.3.

7.4.3.1 Illustrative U.S. manufactured medium-duty trucks are given in Table 4.

7.4.3.2 Table 4 is not all inclusive; comparable vehicles may be acceptable as a test vehicle.

7.4.3.3 The ballast will be standard, round, "open top" (removable top, secured with ring and nut/bolt, or level-lock mechanism), 208-L (55-gal) metal drums filled with soil. The 208 L (55-gal) drums are typically 610 mm (24 in.) in diameter

TABLE 3 Recommended Soil Foundation Material (from AASHTO M147-65)

Sieve Size, mm (in.)	Mass % Passing
50.0 (2)	100
25.0 (1)	75-95
9.5 (⅜)	40-75
4.75 (No. 4)	30-60
2.00 (No. 10)	20-45
0.425 (No. 40)	15-30
0.075 (No. 200)	5-20

TABLE 4 Typical U.S. Medium-Duty Trucks

Make	Model	GVW, kg (lb)
Ford	F650	8850 – 11 800 (19 500 – 26 000)
Ford	F700	11 100 – 13 800 (24 500 – 30 500)
Chevrolet	C6500	9530 – 11 800 (21 000 – 26 000)
Freightliner	FL60	8170 – 12 000 (18 000 – 26 500)
International	4700 DT466E	6130 – 11 800 (13 500 – 26 000)
International	1652	9750 – 12 700 (21 500 – 28 000)

and 883 mm (34 ¾ in.) in outside height. (ISO "containerizable" steel drums may also be used. These are 595 mm (23 7⁄16 in.) with the same inside diameter as the standard 208-L (55-gal) drum. Three horizontal cargo straps and a minimum of one cargo strap over the top of each row of steel drums are required. Photos of a typical test vehicle configuration and ballast attachment using 4540 kg (10 000-lb) ultimate capacity cargo straps are shown in Figs. 1 and 2.

FIG. 1 Typical Test Vehicle Configuration, Side View

FIG. 2 Typical Ballast Attachment, Rear View

7.4.4 *Heavy Goods Vehicle*—The heavy goods vehicle shall be a tandem axle dump truck or tandem axle with drop axle with a minimum gross vehicle mass of 27 300 kg (60 000 lb) and shall be tested at 29 500 ± 590 kg (65 000 ± 1300 lb). Ballasting shall be achieved by the placement of mass concrete in the bed of the dump truck. The concrete shall achieve 70 % of the mix design strength before testing is conducted.

7.5 *Vehicle Penetration Limitations:*

7.5.1 *Discussion*—Most agencies are concerned with the location of the potential explosives relative to the facility being protected. Therefore, likely placements of the explosives will be in the passenger compartment or trunk of the passenger car and in the cargo beds of the pickups and larger vehicle. Hence, the measurement vehicle referenced points discussed in the following.

7.5.2 *Reference Points*—Limits on vehicle dynamic penetration shall be referenced to the original pretest reference point of the barrier being tested. On the small passenger car, the measurement shall be from the barrier reference point to the base of the "A" pillar during peak dynamic penetration. For the remaining three vehicles, the pickup, the medium-duty truck, and the heavy goods vehicle, the penetration measurement shall be from the barrier reference point to the furthest dynamic penetration point of the leading lower bed edge of the vehicle. See Annex A1 and Figs. X2.1-X2.4 in Appendix X2. Reference points on undefined types of barriers shall be determined by the test director.

7.5.3 *Vehicle Penetration Ratings*—In Table 2, penetration ratings for the predetermined limits P1, P2, and P3 and undefined penetration rating, P4, are assigned. The dynamic penetration distance shall be reported and assigned one of the following penetration ratings.

8. Preparation of Apparatus

8.1 *Test Article:*

8.1.1 Each device, assembly, or structure used in a barrier shall be identified and documented by engineering drawings and specifications.

8.1.1.1 All proprietary information shall be clearly indicated in the documents. All such information provided to the test director shall be safeguarded and shall not be disclosed to unauthorized personnel.

8.1.1.2 Each drawing shall include the barrier title/description, drawing number, and date and shall be submitted in A4 (8½ by 11-in.) format. Each drawing shall identify the barrier in exact detail. Assembly drawings shall show the arrangement, locations, and dimensions of all components.

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

8.1.2 Standard commercial materials used in construction shall conform to configuration and performance standards established for the material by appropriate industrial specifications and shall be cited in the specifications.

8.1.3 Nonstandard materials or devices used in configurations not otherwise controlled by recognized industrial or manufacturer specifications shall be accompanied by full-disclosure drawings and specifications.

8.2 *Test Article Installation:*

8.2.1 For gates, adjacent structures used to support the gate and resist induced forces during the crash test shall be specified and documented. Such structures (including their foundations) are considered to be part of the test article and shall be documented in the test report.

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

8.2.3 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.

8.2.4 Other test articles or vehicle arrest devices such as ditches and berms may be evaluated by this test method provided they have adequate descriptions, drawings, and specifications.