Designation: E3211 – 22

Standard Practice for Selection, Integration, and Verification of Active Vehicle Barrier Safety Devices[1]

This standard is issued under the fixed designation E3211; 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.

1. Scope

1.1 This practice is intended to provide methods for selecting, integrating, and verification of active vehicle barrier safety devices so that vehicle barrier systems are reliably and safely controlled when in operation.

1.2 There are a number of risks associated with the operation and use of active vehicle barrier systems (AVBS). One of the risks is that of undesired collision between an active vehicle barrier (AVB) and an authorized vehicle. Such risks can be minimized through proper design, construction, installation, operation, and training in the use of such systems.

1.3 The proper selection, installation, and use of safety devices that will prevent an AVBS from activating or deploying while an authorized vehicle is transiting the barrier, or when such an authorized vehicle is stopped while a portion of the vehicle is located in the path of or in an unsafe proximity to a barrier, can minimize the likelihood of unintended collision between a barrier and authorized vehicle.

1.4 For this practice, safety refers to the ability of the barrier to operate without causing unintended damage to vehicles or injury to people via operation or deployment of the barrier, when an authorized vehicle is transiting the barrier. Security refers to the ability to operate or deploy the barrier to serve its intended purpose of stopping an unauthorized vehicle from passing through the barrier location.

1.5 Pedestrians are excluded from the scope of this practice. It is assumed, for the purposes of this practice, that pedestrians are excluded from potentially hazardous locations in the immediate vicinity of AVBS moving components. It is recognized that authorized pedestrians may be present in the area of the movable AVBS for required purposes, such as inspection of vehicles that are stopped. The presence of "casual" pedestrians shall be kept away from the movable elements of the AVBS.

1.6 This practice is not intended to address any of the following:

1.6.1 Overall performance of vehicle barrier systems or effectiveness as a barrier against any vehicles (see Test Method F2656/F2656M).

1.6.2 Impact energy able to be withstood by vehicle barrier systems.

1.6.3 Serviceability of barrier systems.

1.6.4 Selection of vehicle barrier systems for any particular use.

1.6.5 *Pedestrian Detection Safety Devices*—This practice considers that pedestrians are excluded from hazard zones in the vicinity of vehicle barrier systems; and that only trained and authorized people, such as maintenance staff and security officers performing necessary functions, will be present in the hazard areas when the active barriers are in operation.

1.6.6 Design and installation of vehicle barrier systems, other than performance of associated vehicle detection safety devices, and the verification that safety devices are able to be overridden under designated emergency conditions, as required by owners.

1.6.7 Operating procedures or instructions for operational use of active vehicle barrier systems once they are installed and placed into service. Although such operating procedures are essential for the safe operation of AVBS in practice, development and implementation of such procedures is beyond the scope of this practice.

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

[1] This practice is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.05 on Physical and Electronic Security.

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Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2200 Specification for Automated Vehicular Gate Construction

F2656/F2656M Test Method for Crash Testing of Vehicle Security Barriers

2.2 *ANSI/UL Standard:*[3]

ANSI/UL 325 Standard for Safety – Door, Drapery, Gate, Louver, and Window Operators and Systems

2.3 *ASHRAE Standard:*[4]

Guideline 0 "The Commissioning Process."

2.4 *IMSA Standards:*[5]

Specification 50-2 Polyethylene insulated, polyethylene jacketed, loop detector lead-in cable

Specification 51-1 Polyvinyl chloride insulated, nylon jacketed loop detector wire

Specification 51-3 Cross linked polyethylene insulated loop detector wire

Specification 51-5 Polyvinyl chloride insulated, nylon jacketed, loosely encased in a polyvinyl chloride or a polyethylene tube loop detector wire

Specification 51-7 Cross linked polyethylene insulated loosely encased in a polyvinyl chloride or a polyethylene tube loop detector wire

2.5 *NFPA Standard:*[6]

NFPA 70 National Electric Code (NEC)

3. Terminology

3.1 *Definitions:*

3.1.1 *active vehicle barrier, AVB, n*—mechanized and controlled barrier that is capable of stopping a moving vehicle, automatically or manually operated to place or remove an obstruction in the path of a vehicle to prevent such vehicle from passing through the barrier when the lane is closed.

3.1.2 *active vehicle barrier system, AVBS, n*—mechanized system, complete with all associated controls and devices that may be installed in the factory or in the field to effect operation of an active vehicle barrier in its installed configuration, to either permit or deny access by automobiles, trucks, or similar transportation equipment; active vehicle barrier system includes an active vehicle barrier along with controls and other devices that may be necessary to operate the barrier in practice.

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

3.1.4 *basis of design, BOD, n*—documentation of the primary decision-making process and assumptions behind design decisions made by the responsible designer to meet the Owner's Project Requirements.

3.1.4.1 *Discussion*—Consult ASHRAE Guideline 0 for additional information regarding basis of design and commissioning.

3.1.5 *bollard, n*—vertical post or series of posts used to channel or restrict vehicular traffic.

3.1.5.1 *Discussion*—Bollards used for vehicle control are usually steel, concrete, or a combination of multiple materials. Bollards may be fixed-in-place, removable, or actively controlled operable/retractable. This practice is concerned primarily with those that are actively controlled to allow or restrict passage of vehicles through a portal or access point.

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

3.1.7 *confidence interval, n*—range of values that may include the true value of a parameter of interest, such as the probability that a barrier will prevent access to an unauthorized vehicle.

3.1.8 *confidence level, n*—probability value associated with a confidence interval; the percentage of times that the confidence interval can be expected to include the true population parameter in the long run.

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

3.1.10 *hazard zone, n*—area in and around the moving components of an active vehicle barrier (AVB) assembly and associated moving elements system in which significant potential for impact or collision exists.

3.1.10.1 *Discussion*—Extent or boundaries of hazard zones may be different under different circumstances or operating conditions. For example, if an active vehicle barrier system (AVBS) and associated moving control components, such as control arms or gates, are used only in an area in which vehicles are stopped, checked, or verified and then permitted to pass through the barrier system at low speed after the access control point is opened, then the hazard zone may only extend a short distance beyond the actual moving components of the system. If, however, the AVB is used in a different manner, such that it is normally retracted (open) and closed to prevent a vehicle that may be moving at a higher speed from passing the control point upon detection of a threat condition, then the hazard zone may be much larger—and dependent on the approach distance and speed of the vehicle.

3.1.11 *interposing relay, n*—electrical control device between two systems that enables one system to connect to—or control—a second electrical circuit while retaining direct electrical isolation between the two systems.

3.1.11.1 *Discussion*—Typically used to control a high-power device or circuit from a low-power control signal.

[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] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

[5] Available from the International Municipal Signal Association, 597 Haverty Court, Suite 100 - Rockledge, FL 32955.

[6] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

3.1.12 *lower confidence bound, n*—lowest value of a one-sided confidence interval; in the context of this practice, the lower confidence bound indicates belief that the estimated probability of success is at least as good as this value, at the confidence level employed, given the test results.

3.1.13 *lower confidence limit, n*—lowest value of a two-sided confidence interval; in the context of this practice, the lower confidence limit indicates belief that the estimated probability that the barrier system will operate as intended is at least as good as this value, at the confidence level employed, given the test results.

3.1.14 *override, n*—type of control in which a system or person can supersede a function or operation.

3.1.14.1 *Discussion*—For example, an override switch that would enable an operator to cause a barrier to be deployed regardless of the inhibiting status of an automatic safety device or a manual disable control that disables movement of an AVB could both be considered override controls.

3.1.15 *override, v*—control action taken by an operator or another system to supersede a function or operation.

3.1.16 *owner's project requirements, OPR, n*—written documentation of the functional requirements of the facility or system and the expectations of how it will be used and operated.

3.1.16.1 *Discussion*—Term is from ASHRAE Guideline 0. The owner is not always the end user or operator of a system. In many cases, the owner may be responsible for providing a facility or system to meet end-user or other agency's requirements. For example, within the U.S. Government, one agency (such as the General Services Administration) may be considered to be the owner, but another agency (tenant agency or other end-user organization) may have actually determined the functional requirements of the facility or system.

3.1.17 *rated barrier, n*—vehicle security barrier tested in accordance with Test Method F2656/F2656M by an accredited facility that achieves a given condition designation and penetration rating based on the distance traveled after impact.

3.1.18 *responsible authority, RA, n*—person responsible for some aspect of requirements for this practice.

3.1.18.1 *Discussion*—Responsible authority has responsibility for some aspect of the AVB equipment or system that is the subject of this practice. Responsible authority may—or may not—be different than authority having jurisdiction (AHJ). For example, the engineer of record (EOR) may be the responsible authority for technical design of the AVBS, but the responsible authority for determining owner's requirements for AVBS that the equipment or system is designed to meet may be someone other than the EOR. Contracting officer is typically the responsible authority for contract matters.

3.1.19 *sequence of operations, SOO, n*—written narrative describing control order and action of how a system responds to a set of stimulating conditions or commands.

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

3.1.21 *test director, n*—employee of the testing entity, commissioning agent, third-party testing firm, contractor, or other entity responsible for all aspects of a test.

3.1.22 *tester, n*—person actually performing or controlling tests in the field.

3.1.23 *test vehicle, n*—designated vehicle for specific barrier operation testing.

3.1.24 *upper confidence limit, n*—highest value of a two-sided confidence interval; in the context of this practice, the upper confidence limit indicates belief that the estimated probability that the barrier system operates as intended is no better than this value, at the confidence level employed, given the test results.

3.2 *Acronyms:*

3.2.1 *AHJ*—Authority Having Jurisdiction

3.2.2 *ASHRAE*—American Society of Heating, Refrigerating and Air Conditioning Engineers

3.2.3 *AVB*—Active Vehicle Barrier

3.2.4 *AVBS*—Active Vehicle Barrier System

3.2.5 *BOD*—Basis of Design

3.2.6 *CL*—Confidence Level

3.2.7 *EOR*—Engineer of Record

3.2.8 *GSA*—General Services Administration

3.2.9 *IMSA*—International Municipal Signal Association

3.2.10 *ISO*—International Standards Organization

3.2.11 *LCB*—Lower Confidence Bound

3.2.12 *OPR*—Owner's Project Requirements

3.2.13 *OR*—Operational Requirement

3.2.14 *RA*—Responsible Authority

3.2.15 *SOO*—Sequence of Operations

4. Significance and Use

4.1 There have been instances in the past in which undesired collisions between authorized vehicles and AVBS have occurred. Properly selected, designed, and installed safety devices that are able to inhibit deployment of active barriers when authorized vehicles are in the hazard detection space, in direct proximity to the barrier, can minimize the likelihood that such accidents occur.

4.2 Unintended barrier/vehicle collisions can be very hazardous, will frequently result in significant damage to property, and can also result in personal injury or death, depending on conditions surrounding an incident.

4.3 It is recognized that some vehicle types may not be reliably detected by an individual detection device and an owner may desire placing AVBS in service even though not all vehicle types may be reliably detected. In such determination of use, an owner shall carefully consider such system performance limitations and safety risks, appropriate alternative controls that will minimize safety hazards, and what risks are able to be accepted before placing equipment into service. This practice is intended to provide the owners, designers, installers, integrators, and equipment providers with information that

may be important to such decisions, but it is not intended to determine what risks/hazards are acceptable.

4.4 It is also recognized that there may be particular conditions in which an owner may determine that it is not acceptable to have safety devices installed in AVBS. For example, there may be conditions under which the security risks are determined to be more important to an owner than the possible safety hazards. In such circumstances, the owner shall accept the safety risks and possible consequences that are associated with such a determination that safety devices will not be used.

4.5 If an owner determines that safety devices are not to be used, then it is possible that the owner may choose to implement some alternate means to mitigate or reduce a portion of the safety risks.

5. Design and Performance Requirements

5.1 Active vehicle barrier systems must be designed and installed with appropriate controls and safety devices/sensors to function properly as a system, in a safe manner. This practice addresses the integration of safety devices that are intended to prevent unintended activation of the barrier in the presence of authorized vehicles. Comprehensive selection, design, integration with controls, installation, and testing of AVBS is left to other standards.

5.2 Unless specifically identified by the owner of the facilities or processes protected by the systems, all AVBS shall have safety devices integrated into the design, implementation, and operation of the systems to minimize or prevent unintended system activation when authorized vehicles are present in the hazard zone during operational use.

5.2.1 If an owner determines that it is essential to install or operate an AVBS without such safety devices, the reason(s) for such system configuration shall be documented and acknowledged by the owner, or by an authorized owner's representative. A written acknowledgement and acceptance statement shall clearly state that potential hazards and risks of such configuration are understood and accepted by the owner.

5.3 Safety devices shall prevent an AVB from deploying when a vehicle is in a designated hazard zone in close proximity to a moving portion of an operating barrier.

5.4 Safety devices may be overridden in cases of immediate emergency by manually initiated control action, if such control is designed or specified, and required by the owner. This is sometimes referred to as emergency fast operate, emergency operate, emergency control operate, or similar mode of barrier operation.

5.5 Verification field testing of safety device performance of AVBS, as installed, shall be repeatable with similar results.

6. Installation Requirements

6.1 Installation of active vehicle barriers and active vehicle barrier control systems shall be in accordance with manufacturers' written recommendations and all applicable codes and standards.

6.2 All electrical connections shall be made in above ground electrical boxes, unless using connector types that are listed as suitable for the environment in which they will be installed. Connections in underground locations must typically be specifically approved by the AHJ or the responsible engineer, or both, to be made in underground electrical enclosures. NFPA 70, National Electric Code (NEC) is frequently used as the applicable code reference for electrical wiring, but other requirements may be indicated as well, in addition to the NEC.

6.3 All electrical connections shall be mechanically and electrically sound.

6.3.1 All electrical connections shall be made with terminals/connectors that are designed and manufactured for the application.

6.3.2 All electrical connections with potential of being exposed to moisture shall be sealed to protect against moisture infiltration using connection materials and methods that are rated as being suitable for use in wet locations, or approved by the responsible engineer or AHJ.

6.3.3 All underground electrical connections shall be made using sealed connection materials and methods intended for the application and located in electrical boxes that are adequately protected and drained to prevent accumulation of moisture inside the enclosure.

6.3.4 All wiring and materials installed in underground locations shall be rated for installation/use in such locations.

6.4 Wiring and connections shall use proper grounding and shielding materials and methods necessary to prevent improper operations of vehicle barriers.

7. Other Requirements

7.1 Reserved.

8. Number of Tests and Retests

8.1 All functions and equipment shall be tested.

8.2 Testing should be performed to verify that the entire range of vehicle types expected to transit the barrier are reliably able to transit the barrier safely.

8.3 Since it is impossible to perform an infinite number of tests before placing systems into operational use, a sufficient number of tests shall be performed with each test vehicle type to determine future performance based on accepted probability/statistical methods.

8.4 Responsible authority determines the required statistical performance testing requirements. See Appendix X3 (nonmandatory information) for additional guidance regarding statistical information.

8.4.1 For the purposes of determining test requirements, the responsible authority is the entity determined by the owner who is assigned technical responsibility for establishing the specific test procedures that will be used. The RA may be an employee of the owner, the EOR, a commissioning agent, or other entity determined by the owner.

8.5 Tests shall be statistically independent (that is, the result of a test or trial does not depend on that of a previous test or trial result), and subject to the variability that the system is

likely to encounter under normal operating conditions, so that results obtained can be assumed to be representative of the behavior of the system under actual operation, and the conditions required for the application of the statistical methodology are met.

8.6 Tests shall be performed to ensure that performance of the system with each required test vehicle type has been adequately measured and that defensible conclusions can be drawn.

8.6.1 Results shall be presented as the estimated probability of the system operating correctly, that is, the probability of preventing deployment when an authorized vehicle travels through the system, at all times while passing through the barrier hazard location.

8.6.2 To ensure at least a minimum level of performance, the estimated probability that the barrier system will operate correctly is measured by a specified lower confidence bound (LCB) at a certain confidence level (CL). See non-mandatory Appendix X3 for additional information regarding LCB and CL.

8.6.3 Tests shall be performed including each required vehicle class type. It is understood that separate testing is required to demonstrate performance in preventing access to unauthorized vehicles and to demonstrate performance regarding allowing access to authorized vehicles. The CL and LCB values from each of these separate tests, if both are performed, apply individually to each test only, therefore results shall not be construed as meaning that the combined probability is equal to that of the individual test.

9. Test Vehicles

9.1 It is intended that vehicles defined in Test Method F2656/F2656M, where applicable, are used for testing in accordance with this practice. Where vehicles of different types are identified by an owner as required to be tested (such as motorcycles, compact sedans, mid-size SUVs, large SUVs, full-size pickup trucks, large delivery vehicles, etc.) to verify performance of the various safety devices, the size and characteristics of such vehicles shall be fully documented for the test procedures and reports. At least one vehicle from each required target vehicle type shall be tested to determine performance of safety devices for all required vehicle types. For example, if the owner's requirements include motorcycles, compact cars, mid-size cars, full-size cars, small SUVs, large SUVs, and small delivery trucks, then an acceptable vehicle example from each of the target vehicle types shall be tested, at a minimum. For individual project installations, vehicles to be used for performance tests may be proposed by the tester or contractor installing and testing barriers, but acceptability of the vehicles proposed to be used shall be determined by the owner or designated owner's representative, or both.

9.2 Owner's required vehicle types shall be identified in the contract documents.

9.3 Test vehicles shall be representative of the vehicle types that are expected to transit the barrier systems.

9.4 Motorcycles, large trucks, and vehicles with trailers present particular difficulties for achieving reliable detection using many types of safety detection devices. Modern high-performance motorcycles, for example, may contain such a small amount of metal that they are not able to be reliably detected by loop detectors. Similarly, large trucks may be high enough above the ground that they may only be detected by loop detectors when axles and wheels are present over detection loops, and vehicles with trailers may not be continuously detected as they are transiting past some types of detection devices.

TEST METHODS

10. Scope

10.1 The tests performed shall verify the detection performance of installed AVBS safety devices that are intended to prevent unintended deployment of AVBS barriers in the immediate proximity of authorized vehicles. Tests shall also be performed to verify performance of owner-required override controls that will cause the barriers to deploy even in the immediate presence of authorized vehicles during emergency security conditions as directed by the owner.

10.2 An orderly and comprehensive test plan shall be developed for testing of all components, subsystems, and overall connected/integrated systems. Individual components and subsystems shall be tested before overall connected or integrated systems to ensure that the components and subsystems are operating properly. Once all individual components and subsystems are demonstrated to be operating properly, then the overall connected or integrated system shall be tested.

10.3 Tests shall include physical inspection as well as functional performance verification.

10.3.1 Inspection items should be documented on an inspection checklist.

10.4 All specific test procedures, tests, and test results shall be written in a clear and concise manner, such that test results are repeatable.

10.5 All test documentation and checklists used shall clearly identify name(s) and contact information of test participants. Test documentation shall be signed by the person responsible for the performance of the tests.

10.6 All tests shall be performed in accordance with the test plan.

10.7 Additional test steps determined necessary or appropriate, along with test results, shall be handwritten and added to the test plan. All such additions shall be signed and dated by the test director and tester(s).

11. Safety Hazards During Testing

11.1 Work may be required to be performed in control equipment enclosures with hydraulic or electrical power equipment, wiring, or terminals. Exercise caution when working in proximity to exposed electrical equipment. Work should never be performed in hazardous proximity to or on energized electrical equipment. Hydraulically operated barrier systems may contain hydraulic systems and equipment operating at very high pressures.

11.2 Testing is required to be performed using vehicles moving across or in close proximity to, or both, active vehicle barriers. Caution shall be exercised when moving vehicles across vehicle barriers.

11.3 Movement of AVB and vehicle gate arms can cause injury to people standing or moving in the vicinity of the barriers. People in the vicinity of AVB, gate arms, moving vehicle gates, and operating vehicles shall maintain situational awareness to avoid contact with moving equipment and vehicles. Drivers of test vehicles shall be careful operating vehicles in close proximity to pedestrians, moving barriers, and other obstacles.

12. Inspection

12.1 Inspect the physical installation for use of appropriate materials, proper connections, and any items that may prevent the safety devices from properly performing their intended functions. Document all observations.

13. Test Procedure

13.1 The tests shall be repeatable with consistent results.

13.2 Tests shall be performed with vehicles following typically expected drive paths within the driving lanes. Where card readers or PIN pads are used, it is expected that vehicles will normally drive close to such devices. It is recommended that multiple vehicle paths within driving lanes be tested for each vehicle type, so that the sensor performance can be fully understood. Where tests include motorcycles, sufficient testing should be performed to establish detection performance of the sensors at multiple locations in the driving lane. No other bias is considered for this practice.

13.3 Performance tests are conducted with the barrier system in fully operational condition, except that safety device sensitivity tests should be performed with the actively moving barrier elements of the barrier system de-energized, so that the actively moving barrier elements will not operate during the performance of safety device detection sensitivity tests and the tests can be performed safely. The overall barrier system is required to remain powered during the device sensitivity tests.

13.4 Determine the required confidence level and lower confidence bound that shall be achieved by the system (this should have been determined before design and installation). Statistical information regarding the number of test trials can be found in Appendix X3.

13.5 Review all pertinent design documents.

13.6 Determine target vehicle(s) to be used for the test. Target vehicle(s) selected shall include an entire range of vehicle types and sizes that are normally intended to pass through the barrier system, as indicated in the owner's project requirements, basis of design, design/contract documents, or operational requirements, or combinations thereof. Normally, identification of such vehicle types and sizes is expected to be indicated and documented in an owner's project requirements document or a BOD document.

13.7 Document all inspection criteria on the checklist.

13.8 All equipment shall be de-energized, locked out, and tagged out while performing the following physical inspections.

13.8.1 Perform physical inspection of each subsystem to ensure conformance to design documents and requirements of this practice.

13.8.2 Verify that all required vehicle sensors that are used as safety devices, such as vehicle loop detectors, loop wiring, other types of vehicle detection devices, photoelectric beams, or other devices intended to prevent undesired operation, have been installed and connected to the AVBS controls.

13.8.3 Verify that installed safety devices are suitable for the environment and surroundings in which they are installed.

13.8.4 Verify that all wiring has been installed and is suitable for the intended application and physical environment.

13.8.5 Verify that all electrical power connections and wiring are mechanically and electrically solid.

13.8.6 Verify that isolation devices, such as interposing relays or other devices, that have been approved by the manufacturer, responsible engineer, or designated authority, are installed and properly connected between the automated access control system and the control circuits of the AVBS.

13.8.7 Verify that vehicle safety devices, as installed, are collectively able to reliably detect the presence of all target vehicles located in the hazard zone (in direct proximity of the active barrier). Detection coverage shall be complete in the direct movement area of the barrier. No portion of the vehicle may be located in the direct path of an active barrier while the vehicle is not detected by the safety devices.

13.9 Tests shall be performed for all vehicle types in the intended direction(s) of movement regardless of the orientation of the barrier system. See Fig. 1 (single-direction movement) and Fig. 2 (bi-directional movement through the barrier system) for schematic example illustration.

13.9.1 If intended vehicle movement across a barrier is in a single direction, then performance tests shall be performed in the intended direction of movement, but it does not need to be performed in the opposite direction.

13.9.2 If intended vehicle movement across a barrier is bi-directional, then the performance tests shall be performed in both directions.

13.10 Verify that the installed safety devices do not falsely detect the presence of a vehicle when none are present in the defined hazard zone of the active barrier during normal system operation. The result is not acceptable if safety devices provide unintended detection that prevents the barrier from operating correctly.

13.11 *Perform Safety Detection Device Sensitivity Tests:*

13.11.1 No changes in device settings are permitted to be made during the detection sensitivity performance tests. If observed performance requires device settings to be changed, then the entire series of device detection sensitivity tests for all test vehicles shall be started over from the beginning.

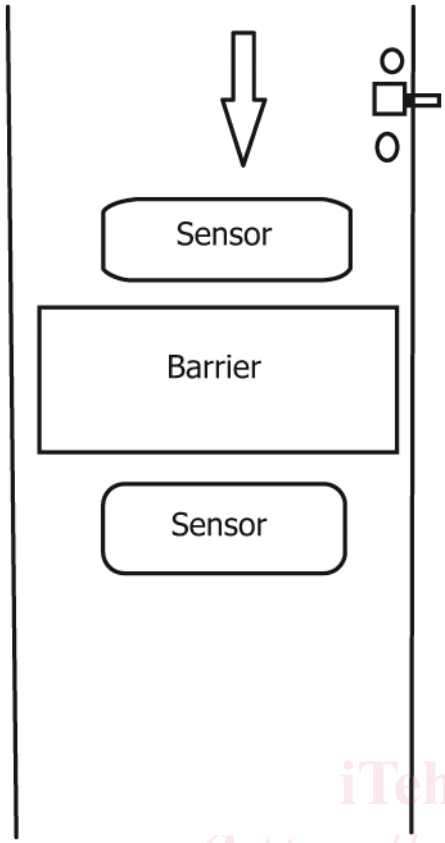

FIG. 1 Single Direction of Movement

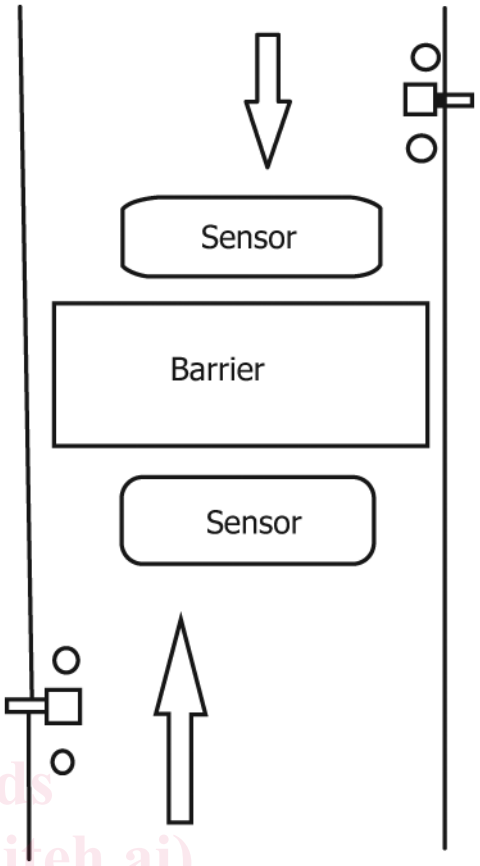

FIG. 2 Bi-Directional Movement

13.11.2 Temporarily disable barriers under test along with any associated moving traffic control devices, such as gate arms, in the fully retracted position (lane is open to unobstructed vehicle passage), so that they will not deploy during this portion of the test. All other components of the system shall be operational.

13.11.3 Using Test Vehicle 1, approach the first safety detection device slowly and document where the vehicle was detected. It is useful to select a fixed point, such as the closest edge of the movable portion of the barrier, and measure the distance from the vehicle to the fixed point. Other fixed points may be used, but they should be referenced to the closest edge of the movable portion of the barrier. Once the vehicle is detected, continue forward movement of the test vehicle and document the locations where each device detects and subsequently loses detection of the test vehicle. Ideally, the test vehicle should be detected by at least one of the safety detection devices at all times while the vehicle is in a position to be impacted by the movable portion of the barrier and any associated moving traffic control devices, such as gates or gate arms.

13.11.4 Repeat the test for the specified number of trials to achieve the required probability and confidence.

13.11.5 Create a detection map showing where the vehicle was detected by each safety detection device relative to the barrier(s) and any moving traffic control devices in each lane for each test vehicle. Refer to Fig. 3 and results data Table 1 for illustration of example layout and distances to be measured.

13.11.6 Repeat the previous safety device sensitivity detection tests for each of the other test vehicles and document the results.

13.11.7 If presence is detected by all safety devices, but overall detection is not continuously detected by at least one safety device through the barrier hazard zone, then document the gaps in coverage in the test report.

13.12 *Perform Safety Detection Device Functional Tests:*

13.12.1 Safety detection device functional tests are used to verify that the provided safety detection devices prevent the barriers from deploying when one or more of the safety devices detects presence in the immediate vicinity of the moving portion of the barrier(s) or moving portions of associated traffic control devices. During the performance of this test, all elements of the AVBS shall be operating.

13.12.2 Using a vehicle simulation device to cause vehicle detection by the various safety detection devices, verify that vehicle barrier(s) and associated traffic control equipment do not deploy while one or more of the detection devices are active, and document the results in the test report.

13.12.2.1 Vehicle simulation device in this step is only intended to activate the various safety detection devices to verify that, when the safety device detects a vehicle, the safety device prevents activation of the barrier and associated movable traffic control equipment. Thus, the characteristics of the vehicle simulation device are not important as long as it causes detection of the safety device.