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Standard Practice for
Installing Piezoelectric Highway Traffic Sensors[1]

1. Scope

1.1 This practice covers the installation of piezoelectric tire-force sensors that are used to detect axles when counting, classifying, or weighing vehicles as part of a roadway traffic monitoring program. Piezoelectric sensors are often used in pairs and combined with other roadway sensors such as inductive loops to classify and weigh vehicles.

1.2 The practice applies only to piezoelectric tire-force sensors used for the detection of vehicle axles on a roadway.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are for information only and are not considered standard.

1.4 *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 determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E867 Terminology Relating to Vehicle-Pavement Systems

E1318 Specification for Highway Weigh-In-Motion (WIM) Systems with User Requirements and Test Methods

E1442 Practice for Highway-Traffic Monitoring (Withdrawn 2001)[3]

E1572 Practice for Classifying Highway Vehicles from Known Axle Count and Spacing (Withdrawn 2002)[3]

E1957 Practice for Installing and Using Pneumatic Tubes with Roadway Traffic Counters and Classifiers

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *axle*—axis oriented transversely to the nominal direction of vehicle motion and extending the full width of the vehicle, about which the wheels at both ends rotate.

3.1.2 *axle count*—number of vehicle axles that are enumerated at a point on a lane or roadway during a specified time interval.

3.1.3 *axle counter*—a device that receives signals from an axle sensor and indicates the cumulative number of axles that have been detected by the sensor during a specified time interval.

3.1.4 *axle spacing*—horizontal distance between the center of a vehicle axle and that of the preceding axle on the vehicle.

3.1.5 *machine count*—cumulative number of axles, vehicles, or vehicles within specified classes, or all of these, indicated or recorded by a traffic recording device for a specified time interval.

3.1.6 *traffic counter*—device that indicates, and usually records, the number of vehicles or vehicle axles, or both, that pass a point on a lane or roadway during a specified time interval.

3.1.7 *traffic recording device*—unit that receives output from a sensor(s) and registers axle count, vehicle count, vehicle classification count, speed, gap, or headway (any or all of these) for defined time intervals.

3.1.7.1 *Discussion*—A traffic recording device may also record axle load and gross-vehicle weight. Refer to Specification E1318.

3.1.8 *vehicle*—one, or multiple, mobile unit(s) designed for travel upon a roadway; a vehicle comprises one powered unit and may include one or more non-powered trailer or semitrailer unit(s).

3.1.9 *vehicle classification count*—cumulative number of vehicles of each defined type (class) indicated or recorded for a specified time interval.

4. Summary of Practice

4.1 *Site Selection:*

4.1.1 Select a relatively straight and smooth section of roadway that is expected to have free flowing traffic throughout the duration of the data collection session.

4.1.2 The selected roadway section should have little to no surface distortion or rutting in the wheel paths.

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[1] This practice is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.52 on Traffic Monitoring.

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[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.

4.1.3 Longitudinal grades and lateral pavement slopes should be less than 3 % as per Specification E1318.

4.1.4 The selected site should have:

4.1.4.1 Access to electrical power or good location for solar and telephone service if data is to be collected continuously for more than a few weeks at a time,

4.1.4.2 Adequate space for an instrument cabinet, with a safe area for a technician to park a vehicle and stand while making adjustments or repairs, and

4.1.4.3 Adequate drainage to prevent standing water in splice boxes and instrument cabinet.

4.1.5 Traffic conditions at the site should include minimal occurrences of stop-and-go traffic, slow-moving traffic, lane changing, and passing on two-lane roads.

4.1.6 Pavement cracks and joints shall be avoided. Do not place a sensor across any crack or joint. Whenever practicable, space sensors a minimum of 1 ft (300 mm) from transverse cracks and contraction joints and 6 ft (1800 mm) from expansion joints.

4.1.7 Pavement thickness and strength must be adequate to sustain the additional stress concentrations that will result from installation of piezoelectric and other associated sensors.

4.1.8 Site requirements for installing weigh-in-motion (WIM) systems are given in Specification E1318.

4.2 *Installation Procedures:*

4.2.1 Installation should be performed in relatively good weather, avoiding extreme heat or cold and moisture conditions that might adversely affect the bonding of grout to the sensor or the pavement.

4.2.2 At the selected site, use a taut string line or a template oriented perpendicular to the flow of vehicular traffic to mark the sensor locations.

4.2.2.1 Colored spray paint applied over the string line or template will provide a more lasting guide for pavement cutting than chalk or crayon.

4.2.3 Use a pavement saw or similar equipment with a competent operator to make the necessary parallel cuts in the pavement.

4.2.3.1 The width and depth of the cut shall be in accordance with the recommendations of the manufacturer of the sensor.

4.2.3.2 When feasible, use a saw blade of proper thickness or gang several thinner blades together to cut the sensor slot in one pass. If two cuts are made for installation, use a hammer and chisel or a small jackhammer to loosen and clean out all material between the two cuts to the required depth.

4.2.3.3 Wash the slot and adjacent surface with clean water, using a high-pressure washer. Assure that no contaminated wash water remains in the slot. Dry the slot and adjacent road surface using compressed air and a blowgun. The air compressor should have a dedicated outlet for the hose and be able to sustain a minimum flow rate of approximately 185 ft^3/min (5 m^3/min). An air drier/oil remover unit should be installed at the compressor outlet. Use a dedicated 50-ft (15-m) section of airline hose for this process. Make sure that all dirt and moisture is removed from the hose before use.

4.2.3.4 Inspect the slot, and use a wire brush or a chisel to dislodge any debris that may still be clinging to its sides and bottom. Again, use compressed air to remove any remaining debris from the slot.

4.2.3.5 After unpacking any type of piezoelectric sensor on-site, test its output signal according to the manufacturer's instructions, making sure the sensor is working properly.

4.2.3.6 Test slot length, depth, and width by lowering the sensor or an accurate template into the slot and look for contact points on the ends, bottom, and sides of the slot. Adjust the size as needed.

4.2.4 When cutting slots for lead-in-wire runs to the edge of the pavement, including the paved shoulder, make every effort to avoid unnecessary horizontal angles and turns.

4.2.5 It is recommended that the sensor lead-in wires be of sufficient length to reach into the equipment cabinet without splicing. When a splice must be made, use an approved underground wiresplice encapsulation kit in accordance with the kit manufacturer's instructions. This helps ensure that moisture will not enter the wire and render the piezoelectric sensor unusable until the splice is replaced. Splices should be housed only in junction and splice boxes. Splices should be structurally strong, electrically sound, and waterproof. Splicing generally requires a well-trained, certified electrician. He or she shall follow the manufacturer's instructions or standard procedures, carefully and exactly.

4.2.6 Cover the pavement surface along both sides of the slot with a three-inch (75-mm) wide strip of gaffer's tape or duct tape.

4.2.7 It is extremely important to always handle the sensor carefully. When installing bare (not-encapsulated) sensors, never handle the sensor without new, powder-free vinyl or latex examination gloves. This keeps the oil from one's hands from contaminating the exposed surface of the sensor. The lead-in wire is especially vulnerable to being pulled away from the sensor element inside. Never bend the sensor so as to break it or so as to form a kink in it.

4.2.8 The exposed surfaces of a bare sensor should be "roughed up" using a medium grade emery cloth or sandpaper.

4.2.9 Clean the exposed surfaces of a bare sensor of any dirt or oily substance with acetone, denatured alcohol, or other similar zero-residue solvent that will not harm the surface or the lead-in wire insulation and will not interfere with the adhering properties of the selected grout.

4.2.10 Use a grout recommended by the sensor manufacturer, or one specifically approved by the sensor user, that will adhere well to the sensor and pavement material and which will cure quickly so as not to delay traffic at the site during installation. Many grout problems stem from incorrect proportions, improper mixing, or entraining air during the mixing process. Consideration may be given to using a dual-canister pneumatic applicator that combines both grout components in an exact mix during the application process, thereby reducing errors commonly experienced with hand mixing.

4.2.11 Prior to mixing grout or beginning grout application, test the sensor output signal again according to the manufacturer's instructions, making sure that the sensor is working properly.

4.2.12 Prepare, handle, and finish the grout in accordance with the recommendations of the sensor manufacturer.

4.2.13 Use grouting procedures recommended by the manufacturer to insure that air voids are not present. Higher-viscosity grouts are more likely to trap air under the sensor.

4.2.14 Following the instructions of the manufacturer, place the sensor in the pavement slot, adjusting its height so that the top of the sensor is positioned according to the manufacturer's specifications. This is usually accomplished by using brackets and or jigs to hold the sensor at the correct height.

4.2.15 With the sensor correctly held in place, carefully fill the pavement slot with grout.

4.2.16 For a bare sensor, use a putty knife, trowel or similar tool, to smooth the grout so that it is flush or just above the road surface. The top of the finished grout surface shall not be below the road surface. It is better to leave too much grout and grind the excess away after it has fully cured than to leave a depression in the roadway that will degrade the sensor signal.

4.2.17 When the grout has partially cured, carefully remove the tape and any additional fixtures from the adjacent pavement surface.

4.2.18 It may be necessary to use an angle or belt grinder to finish the grout so that it is flush with the road surface. Ensure that the grout is fully cured prior to grinding and to opening the lane to traffic.

4.2.19 Route the lead-in wires through the sawn lead-in slots and conduit to the equipment cabinet or to the splice box, making sure not to kink or nick the outer protective insulation (see 4.2.5). Use additional grout or sealant to fill lead wire slots completely to edge of pavement.

4.2.20 With the sensor and lead-in wires in place, test the output signal at the cabinet according to the manufacturer's instructions, making sure that the sensor is working properly.

4.3 *Post Installation Testing:*

4.3.1 Use an oscilloscope to observe the piezoelectric sensor output signal for proper signal strength, good signal-to-noise ratio, and clean pulses when vehicles pass over the sensor.

4.3.2 For applications other than weigh-in-motion, once the piezoelectric sensor(s) have been installed and connected to a suitable traffic recording device, a verification count must be made to determine whether the sensor output signals are being recorded correctly. There should be a mix of vehicles, including those with light, medium and heavy axle loads that will normally pass over the sensor(s).

4.3.3 To make the verification (machine) count, initialize the traffic recording device (that is, note the indicated axle count) and then concurrently have one or more persons count and record manually (manual or validation count) the number of axles that pass over the sensor(s) until at least 50 axles have passed. After this, note the indicated machine count (verification count) on the traffic recording device and calculate the number of axles counted concurrently with the manual count. Compare the machine count with the manual count(s) (validation count(s)) to verify that the axle counts were determined correctly. If more than one person made a manual count, there shall be no more than 2 % difference from the largest value for any count to be acceptable for use in determining the validation count. Repeat the manual counts (and the machine counts concurrently) as necessary until this condition is satisfied; then calculate the mean value of all manual counts and round the mean value to the nearest integer. Use this integer value as the validation count. For acceptable performance, the machine (verification) count should not vary from the validation count more than 4 %, preferably less. Do not begin a data-collection session until the piezoelectric sensor(s) and the associated traffic recording device are performing acceptably.

4.3.4 Recheck the piezoelectric sensor output with an oscilloscope 24 to 48 h later.

4.4 *Maintenance:*

4.4.1 Because of the discontinuity created by cutting the slot for the sensor and lead-in wires, the pavement structure in the vicinity of the sensors is subject to more severe stresses from tire loads than that on the rest of the roadway. A greater potential for accelerated pavement and sensor damage exists; therefore, frequent and careful attention must be given to the condition of the pavement surrounding the sensors and to the proper functioning of the sensors.

4.4.2 An annual or more frequent routine inspection and maintenance program should be established for the site, and necessary corrective actions must be performed in a timely manner. Recommended items for inspection and maintenance include but are not limited to the following: oscilloscope traces, manufacturer's recommended test readings, manual data comparisons, filling of holes and cracks, and so forth.

4.4.3 If data anomalies indicate problems with the site, corrective actions should be taken as soon as possible to avoid erroneous data collection.

5. Significance and Use

5.1 This practice addresses the installation of piezoelectric sensors that support traffic recording devices which are used for monitoring highway traffic characteristics. Thus, this practice provides information that must be used with professional judgment by qualified persons within governmental agencies and private firms to aid in the management of roads and roadway traffic.

5.2 Traffic monitoring is important to the safe and efficient movement of people and goods. The purpose of this practice is to ensure that traffic monitoring procedures produce traffic data and summary statistics that are adequate to satisfy diverse and critical traffic information needs.

6. Keywords

6.1 axle counts; piezoelectric sensors; traffic counters; vehicle axles; vehicle classifiers; vehicles