Standard Practice for

Preparation of Test Specimens Using the Plastic Mold Compaction Device

AASHTO Designation: PP 92-yy[1]
Release: Group n (Month yyyy)

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AASHTO

1. SCOPE

1.1. This standard practice covers the use of the Plastic Mold compaction device (PM Device) to prepare cylindrical test specimens with an approximate 2:1 height to diameter aspect ratio for use in a variety of mechanical property testing (e.g. compressive strength, elastic modulus, tensile strength). This practice is intended for chemically stabilized materials (e.g. soil-cement, cement treated aggregate base, soil-lime). The PM Device has been manufactured in two sizes [76.2 by 152.4-mm (3 by 6-in.) and 101.6 by 203.2-mm (4 by 8-in.)], and the appropriate PM Device size is determined by the particle size distribution of the material being tested.

1.2. Method A utilizes the 76.2 by 152.4-mm (3 by 6-in.) PM Device (also referred to as 3x6) and is intended for material passing a 9.5-mm (3/8-in.) sieve.

1.3. Method B utilizes the 101.6 by 203.2-mm (4 by 8-in.) PM Device (also referred to as 4x8) and is intended for material passing a 19.0-mm (3/4-in.) sieve.

1.4. This standard practice may be to fabricate test specimens in the laboratory or in the field.

1.5. The values stated in SI units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
- M 205, Molds for Forming Concrete Test Cylinders Vertically
- M 231, Weighing Devices Used in the Testing of Materials
- T 99, Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
- T 134, Moisture-Density Relations of Soil-Cement Mixtures
- T 180, Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- T 265, Laboratory Determination of Moisture Content of Soils

2.2. *ASTM Standards:*
- E11-17, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. SIGNIFICANCE AND USE

3.1. This standard practice provides procedures to compact chemically stabilized materials into plastic cylinder molds for the purpose of fabricating a test specimen with a height to diameter aspect ratio of approximately 2:1. Methods of compaction are designed to achieve a desired percentage of a target specimen density which is typically determined using T 99 or T 134.

3.2. Practical uses of this practice include utilizing the PM Device to produce laboratory and field test specimens. This can provide interconnection between pavement layer thickness design testing, mixture design testing, and quality assurance testing during construction. Utilizing the same method of compaction for laboratory and field test specimens will enable more direct comparison of as-built and design properties.

4. APPARATUS

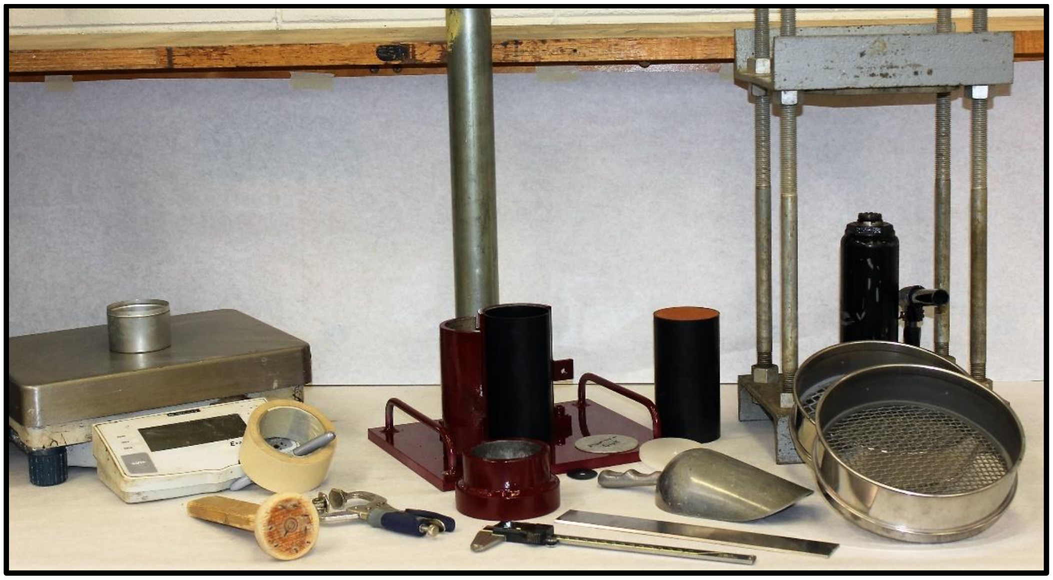

Figure 1—Overview Photo of All PM Device Apparatus Items

4.1. *Plastic Mold Device Assembly (Split-Mold, Collar, and Base Plate)*— Figure 2 shows a representative photo of a PM Device. For both sized devices, the PM Device Assembly consists of the split-mold (labeled A in Fig 2), collar (labeled B in Fig. 2), and base plate (labeled C in Fig. 2). The split-mold and collar shall be made of solid metal, and the base plate may be made of the same solid metal or aluminum. All components shall be manufactured with dimensions and capacities shown in Annex A. The collar shall be approximately 50.8-mm (2-in.) tall to permit preparation of specimens of the desired height and volume. The split-mold component shall be constructed so that it can be fastened firmly to the base plate during operation (see Annex A).

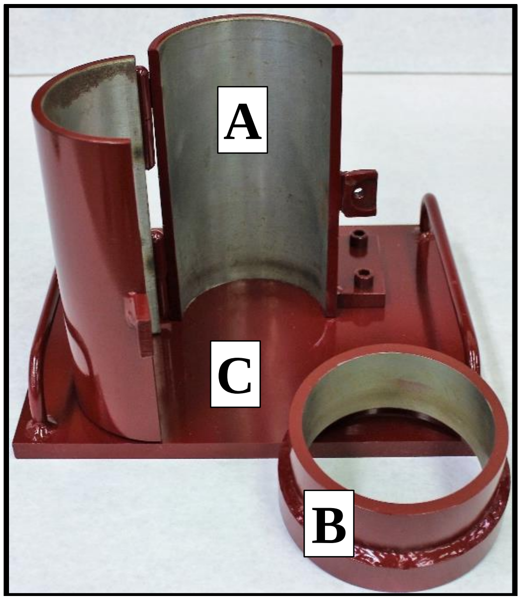

Figure 2—4x8 PM Device Assembly

4.2. *Rammer*—A manual, metal rammer conforming to criteria specified in T 180 (4.54-kg [10-lb] rammer and a 457-mm [18-in.] drop).

4.3. *Plastic Mold Assembly*—The plastic mold assembly used in conjunction with the PM Device consists of a modified cylindrical plastic mold, aluminum plate, and plastic plug. Figure 3 is a photo plastic mold assembly components. The aluminum plate is placed inside the plastic mold and allowed to rest at the bottom of the mold. The plastic plug is taped to the outside bottom surface of the plastic mold to give the mold assembly an even bottom surface for compaction. The plastic mold assembly may be used multiple times.

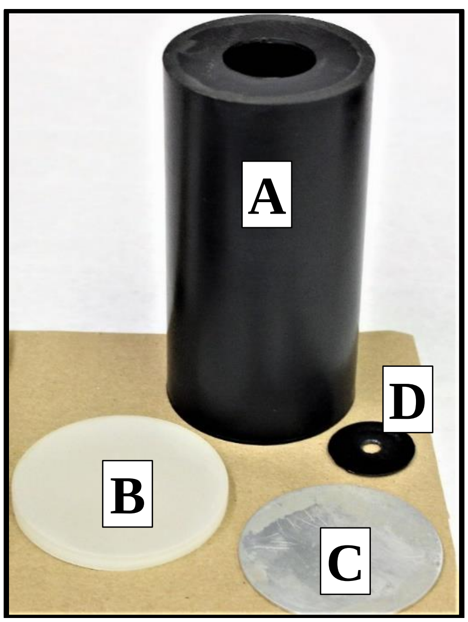

Figure 3—(A) Prepared Plastic Mold, (B) Plastic Lid, (C) Aluminum plate, and (D) Plastic Plug

4.3.1 *Cylindrical Plastic Mold (Mold, Plastic Lid, and Plastic Plug)*—A 76.2-mm (3-in.) diameter by 152.4-mm (6-in.) tall or 101.6-mm (4-in.) diameter by 203.2-mm (8-in.) tall plastic cylinder mold conforming to M 205 may be used. The outside bottom of the plastic mold shall be sanded smooth and a 35-mm (1 3/8-in.) diameter hole cut in the center with a spade drill bit to aid specimen extraction. The plastic plug from cutting process is retained for plastic mold assembly. The plastic lid is used to cover the top surface of the specimen after compaction.

NOTE 1—Plastic molds with a vertical slit have shown the possibility of being an alternative to the plastic molds described in Section 4.3.1. Alternative plastic mold configuration attempts to date by two different laboratories have documented some level of success, but also have identified some challenges. Deviations to the plastic mold described in Section 4.3.1 are permitted if the alternative approach is documented to produce test specimens that are comparable to those produced via the mold configuration shown in Figure 3 in terms of dimensions and mechanical properties. If used, alternative plastic mold modifications should be noted alongside test results.

4.3.2 *Aluminum Plate*—A 75.8-mm (2.984-in.) or a 101.2-mm (3.984-in) diameter aluminum plate with a thickness of 1.59-mm (1/16-in.). The diameter of the aluminum plate corresponds to the inside diameter at the bottom of the plastic mold, and the plate is utilized for the plastic mold assembly.

4.4. *Sample Extruder*—A jack, lever, and frame as shown in Figure 4, or other device adopted for the purpose of extruding compacted specimens from the plastic mold assembly. The jack should be mounted to the frame perpendicular to the extrusion plate. The diameter of the opening in the extrusion plate should be slightly larger than the specimen diameter and have a small lip to catch the edge of the plastic mold assembly to facilitate extraction without specimen damage.

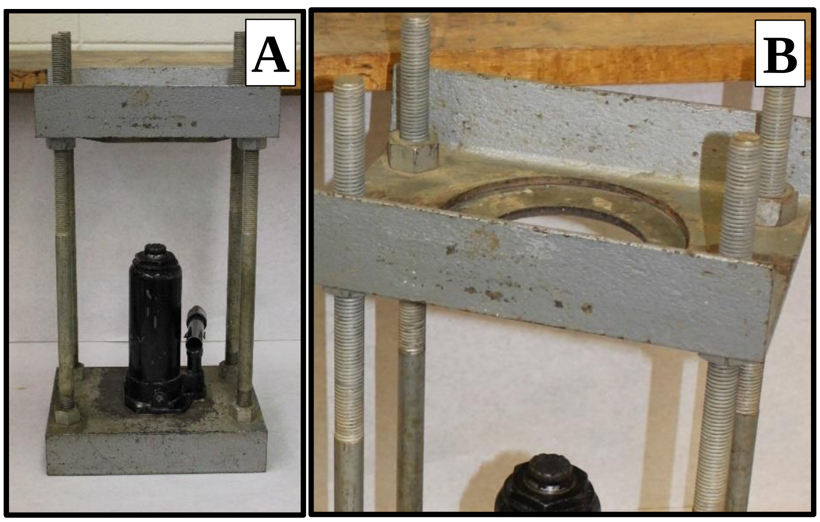

Figure 4—(A) Specimen Extruder and (B) Extruder Plate Opening

4.5. *Straightedge*—A hardened-steel straightedge at least 250-mm (10-in.) in length. It shall have one beveled edge, and at least one longitudinal surface (used for fine trimming) shall be plane within 0.250-mm per 250-mm (0.01-in. per 10-in.) (0.1 percent) of length within the portion used for trimming the soil.

4.6. *Locking Clamp*—A pair of locking pliers (e.g. vise-grips) or clamping tool capable of fastening together the split-mold component of the PM Device during compaction.

4.7. *Sieves*—9.5-mm (3/8-in.), and 19.0-mm (3/4-in.) sieves conforming to the requirements of ASTM E11.

4.8. *Measuring Devices*—Balance conforming to the requirements of M 231, Class G 2 with 0.1 gram resolution and Calipers with appropriate range and minimum resolution of 0.1-mm (0.01-in.).

4.9. *Miscellaneous Tools*—Tape, Scoops, scarifying tool, and labeling materials.

METHOD A – 3X6 PM DEVICE

5. SAMPLE

5.1. For laboratory prepared specimens, thoroughly mix all mixture components (i.e. soil, chemical stabilizer, and water) to a uniform color. For field prepared specimens, take a sample after all components are incorporated and at the completion of all mixing operations. Record the time of initial mixing to the nearest minute.

5.2. Sieve an adequate quantity of representative material over the 9.5-mm (3/8-in.) sieve. Discard the coarse material, if any, retained on the 9.5-mm (3/8-in.) sieve.

NOTE 2—If particle size distribution is of interest, take a secondary sample to determine percentage of coarse particles of the mixture.

5.3. Select a representative sample, with a mass of approximately 3-kg (7-lb) or more, of mixed chemically stabilized material to fabricate a test specimen. Determine the moisture content of the sample immediately before compaction according to T 265.

6. PROCEDURE

6.1. Insert the plastic mold assembly into the split-mold component of the 3x6 PM Device as shown in Figure 5a. Secure the PM Device together at the latch with the locking clamp. Place the collar on top of the device. The PM Device shall rest firmly on a dense, uniform, rigid, and stable foundation or base during compaction. Figures 5b and 5c are photos of the PM Device ready to begin specimen preparation.

NOTE 3—Each of the following are considered to be a satisfactory base on which to rest the PM Device during compaction: a block of concrete, with a mass of not less than 90-kg (200-lb), supported by a relatively stable foundation; a sound concrete floor; and for field application, such surfaces as are found in concrete box culverts, bridges, and pavements.

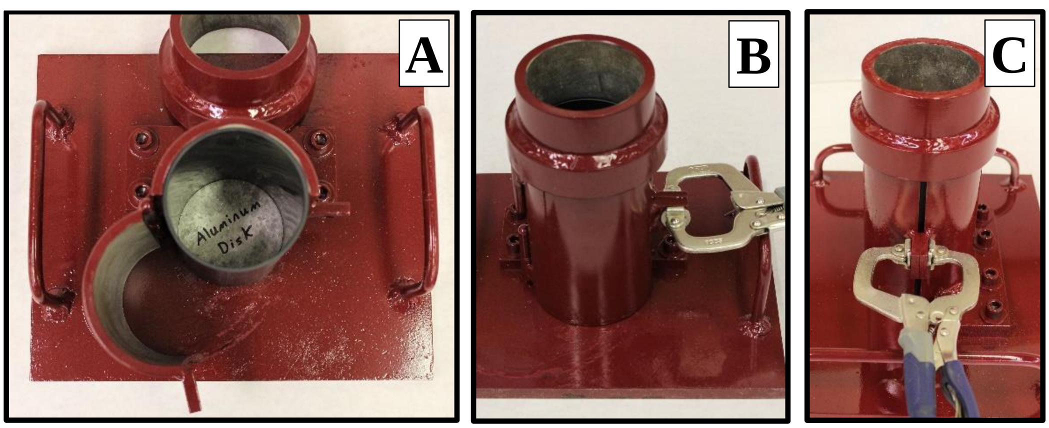

Figure 5—(A) 3x6 PM Device with Plastic Mold Assembly, (B & C) PM Device Ready for Use

6.2. Form a specimen by compacting the sampled material into the plastic mold assembly in three approximately equal layers. Compact each layer with a prescribed number of uniformly distributed blows from the 4.54-kg (10-lb) rammer dropping free from a height of 457-mm (18-in.) above the elevation of the stabilized soil. A minimum of 4 blows are to be applied to each layer, but more blows may be used to achieve desired specimen density. The number of blows shall be the same for each layer. Use a scarifying tool to scarify the top surface of layers before compacting subsequent layers to prevent compaction planes within the specimen. After compaction approximately 6.4-mm (0.25-in.) of compacted material should extend above the top of the plastic mold. Record the time of compaction completion to the nearest minute.

NOTE 4—Compaction approach presented is intended to produce test specimens with an appropriate specimen density. Appendix X2 provides a procedure to determine the number of blows per layer to achieve a desired specimen density.

6.3. Remove the collar and plastic mold from the PM Device. Carefully trim the compacted specimen even with the top of the plastic mold by means of a straight edge. Immediately place the plastic lid on top of the specimen.

6.4. Label specimens with appropriate information and allow to cure inside the plastic mold for at least 24 hours before extruding the test specimen. To extract the specimen from the plastic mold assembly, remove the plastic plug and use a sample extruder. The jack should press against aluminum plate during extraction to prevent specimen damage. Curing conditions should be reported (e.g. on lab bench at room temperature, at project site, etc.).

6.5. Once extruded, remove the aluminum plate from the bottom of the specimen. Measure specimen mass with a balance and specimen volume with calipers. Measured moisture content can be used to calculate dry density. The specimen is now ready for additional curing and/or mechanical property testing.

NOTE 5—Guidance on expected specimen dimensions is given in Appendix X1.

METHOD B – 4X8 PM DEVICE

7. SAMPLE

7.1. For laboratory prepared specimens, thoroughly mix all mixture components (i.e. soil, chemical stabilizer, and water) to a uniform color. For field prepared specimens, take a sample after all components are incorporated and at the completion of all mixing operations. Record the time of initial mixing to the nearest minute.

7.2. Sieve an adequate quantity of representative material over the 19.0-mm (3/4-in.) sieve. Discard the coarse material, if any, retained on the 19.0-mm (3/4-in.) sieve.

NOTE 6—If particle size distribution is of interest, take a secondary sample to determine percentage of coarse particles of the mixture.

7.3. Select a representative sample, with a mass of approximately 6-kg (14-lb) or more, of chemically stabilized material to fabricate a test specimen. Determine the moisture content of the sample immediately before compaction according to T 265.

8. PROCEDURE

8.1. Insert the plastic mold assembly into the split-mold component of the PM Device and secure the PM Device together at the latch with the locking clamp. Place the collar on top of the device. The PM Device shall rest firmly on a dense, uniform, rigid, and stable foundation or base during compaction. Refer to Figure 5 for visuals of this concept.

NOTE 7—Each of the following are considered to be a satisfactory base on which to rest the PM Device during compaction: a block of concrete, with a mass of not less than 90-kg (200-lb), supported by a relatively stable foundation; a sound concrete floor; and for field application, such surfaces as are found in concrete box culverts, bridges, and pavements.

8.2. Form a specimen by compacting the sampled material into the plastic mold assembly in four approximately equal layers. Compact each layer with a prescribed number of uniformly distributed blows from the 4.54-kg (10-lb) rammer dropping free from a height of 457-mm (18-in.) above the elevation of the stabilized soil. A minimum of 5 blows are to be applied to each layer, but more blows may be used to achieve desired specimen density. The number of blows shall be the same for each layer. Use a scarifying tool to scarify the top surface of layers before compacting subsequent layers to prevent compaction planes within the specimen. After compaction approximately 6.4-mm (0.25-in.) of compacted material should extend above the top of the plastic mold. Record the time of compaction completion to the nearest minute.

NOTE 8—Compaction approach presented is intended to produce test specimens with appropriate specimen density. Appendix X2 provides a procedure to determine the number of blows per layer to achieve a desired specimen density.

8.3. Remove the collar and plastic mold from the PM Device. Carefully trim the compacted specimen even with the top of the plastic mold by means of a straight edge. Immediately place the plastic lid on top of the specimen.

8.4. Label specimens with appropriate information and allow to cure inside the plastic mold for at least 24 hours before extruding the test specimen. To extract the specimen from the plastic mold assembly, remove the plastic plug and use a sample extruder. The jack should press against aluminum plate during extraction to prevent specimen damage. Curing conditions should be reported (e.g. on lab bench at room temperature, at project site, etc.).

8.5. Once extruded, remove the aluminum plate from the bottom of the specimen. Measure specimen mass with a balance and specimen volume with calipers. Measured moisture content can be used to calculate dry density. The specimen is now ready for additional curing and/or mechanical property testing.

NOTE 9—Guidance on expected specimen dimensions is given in Appendix X1.

9. REPORTING

9.1. Report relevant mixture information (e.g. sampling location, mix proportions, etc.), number of blows per layer, curing conditions during the 24 hour period, specimen moisture content, specimen dry density, time of initial mixing, time of compaction completion, and plastic mold configuration if different than Figure 3.

10. KEYWORDS

10.1. Plastic Mold Compaction Device; PM Device; Plastic Mold; Soil-Cement; Compaction

ANNEX A—PM DEVICE DRAWINGS

This Annex contains the drawings needed to manufacture the PM Device.

A1. DRAWINGS

A.1.1 Figures A1.1 to A1.5 provide all drawings needed to manufacture the 3x6 PM Device, and Figures A1.6 to A1.10 provide all drawings needed to manufacture the 4x8 PM Device. These drawings coincide with the 7 numbered POINTS below that explain the drawings, note what features shown on these drawings are optional, and provide additional information on the mandatory components of each size PM Device.

POINTS

1) Steel used in the fabrication of the MOLD SUPPORT ASSEMBLY shall be ASTM A36 (or equivalent). Steel pipe used in the fabrication of the MOLD SUPPORT TUBE shall be ASTM A519 (or equivalent).
2) In order to lighten the weight of the finished assembly, the BASE PLATE may be fabricated from aluminum (Grade 3003 o equivalent). If an aluminum base plate is used then bolts, not welds, are to attach the MOLD SUPPORT ASSEMBLY to the BASE PLATE.
3) The BASE PLATE dimensions shown on these drawings are suggested dimensions. The overall size of the BASE PLATE can vary from 10 inch by 12 inch, as shown on these drawings, to as small as 9 inch by 11 inch. The BASE PLATE handles are optional.
4) Six 3/8 inch – 24 UNF bolts, 1 inch long with flat washers can be used to attach the MOLD SUPPORT ASSEMBLY to the BASE PLATE. If a BASE PLATE is fabricated from steel, the MOLD SUPPORT ASSEMBLY may be welded, rather than bolted, to the BASE PLATE.
5) The parts of the MOLD SUPPORT ASSEMBLY shall be put together in such a way that after its completion the MOLD SUPPORT TUBE parts (F11003 & F11005 for the 3x6 mold, and D12003 & D12006 for the 4x8 mold) shall have a common radial axis when the MOLD LATCHES (F11008A & F11008B for the 3x6 mold, and D12008A & D12008B for the 4x8 mold) are bearing on each other.
6) The “Gap” will be of uniform width from 0.13 to 0.25 inches wide and the MOLD SUPPORT ASSEMBLY shall be constructed in such a way that the MOLD SUPPORT TUBE provides continuous support of the plastic sleeve around its vertical sides when the MOLD LATCHES are bearing firmly on each other.
7) Trim a minimum of 0.04 inches off the bottom of Part Number (P/N) F11003 to make P/N F11006 for the 3x6 mold, and trim a minimum of 0.04 inches off the bottom of P/N D12003 to make P/N D12006 for the 4x8 mold.

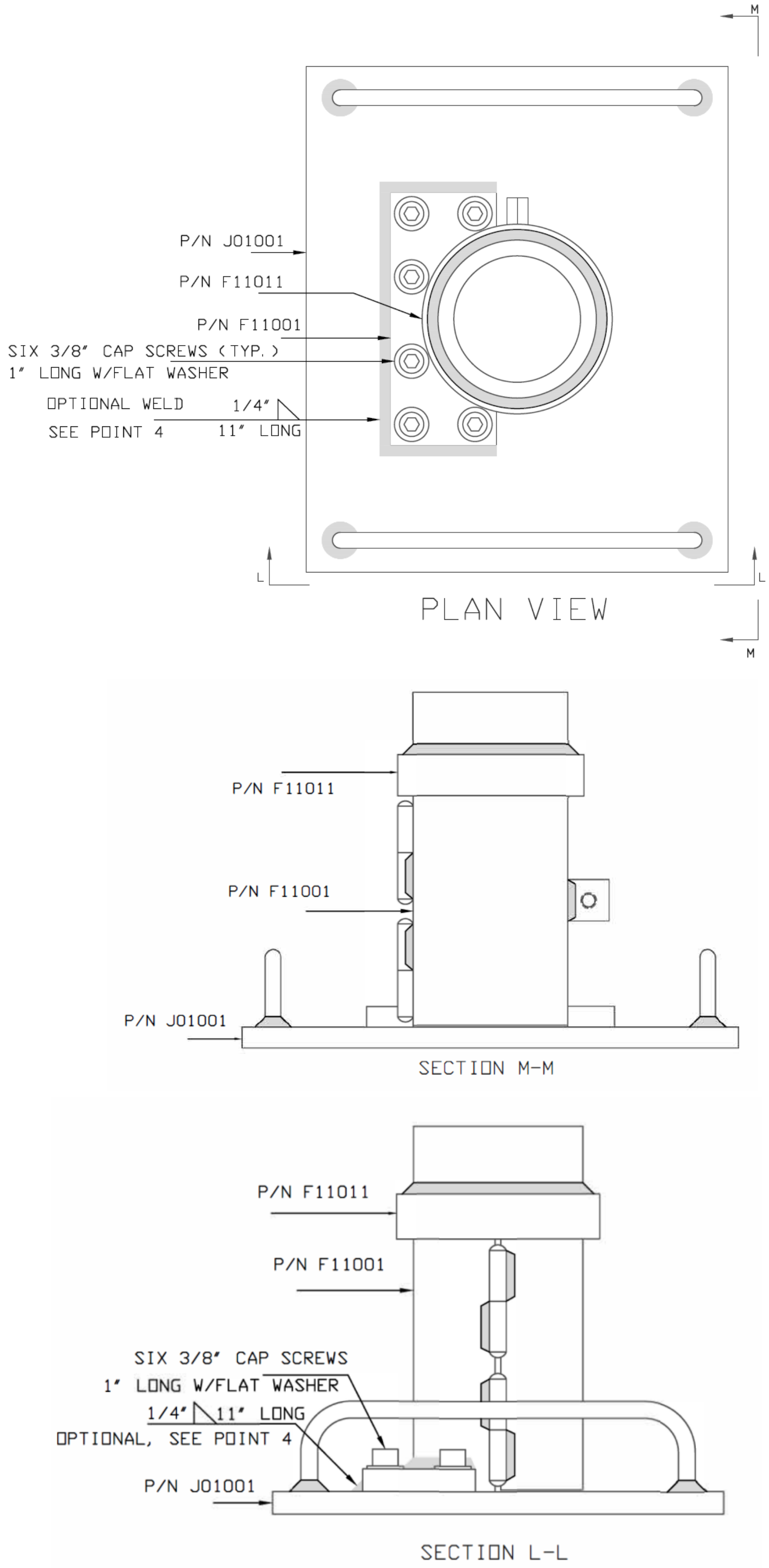

Figure A1.1 – Overall Views of 3x6 PM Device

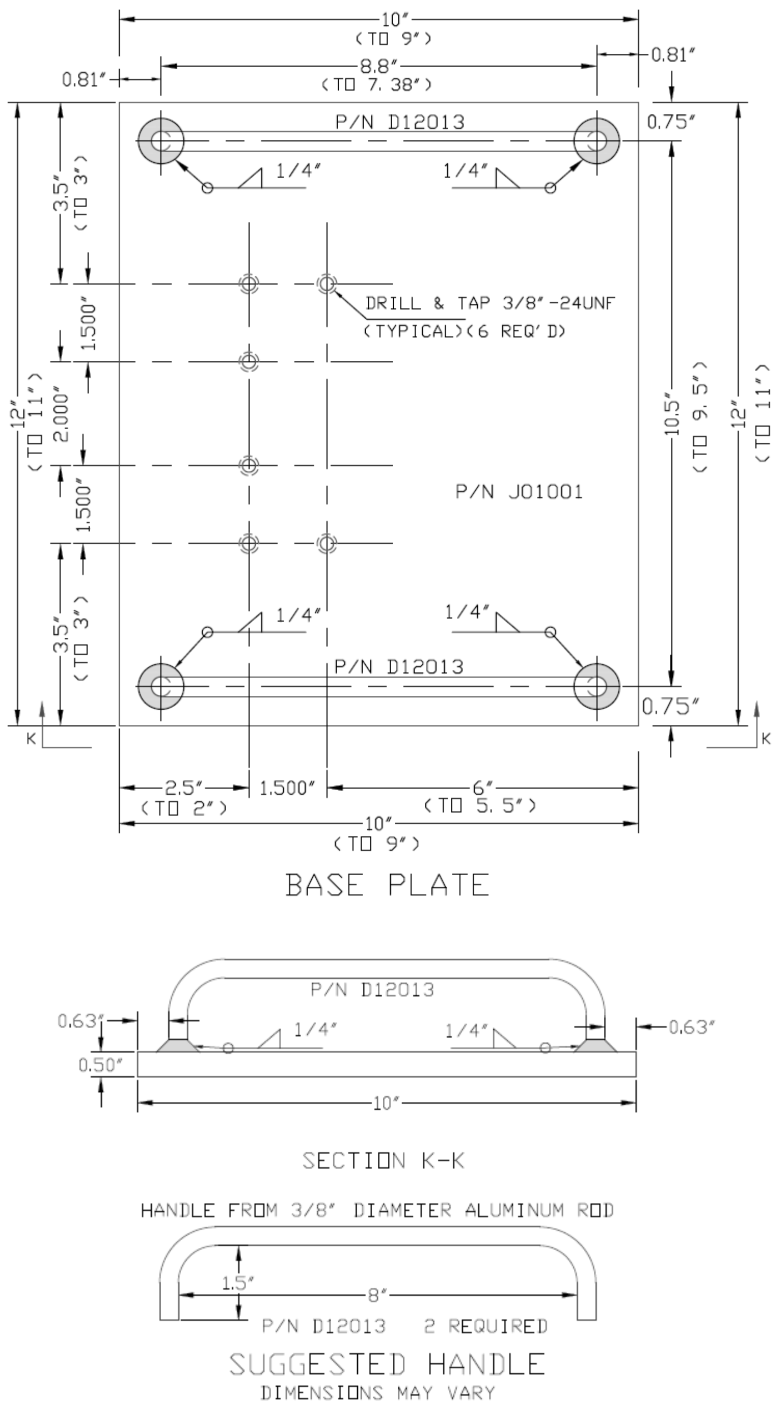

Figure A1.2 –3x6 PM Device Base Plate

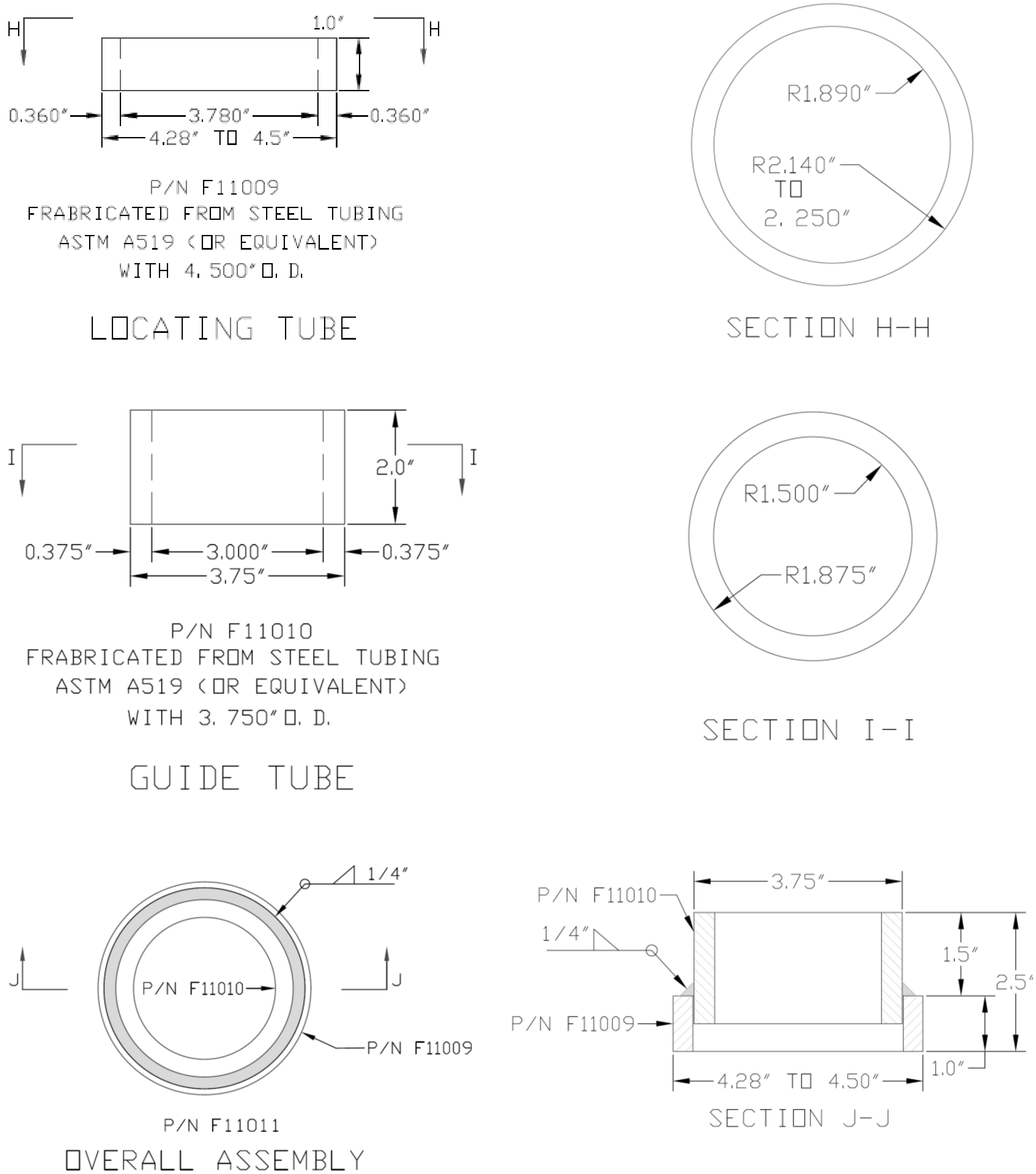

Figure A1.3 –3x6 PM Device Collar

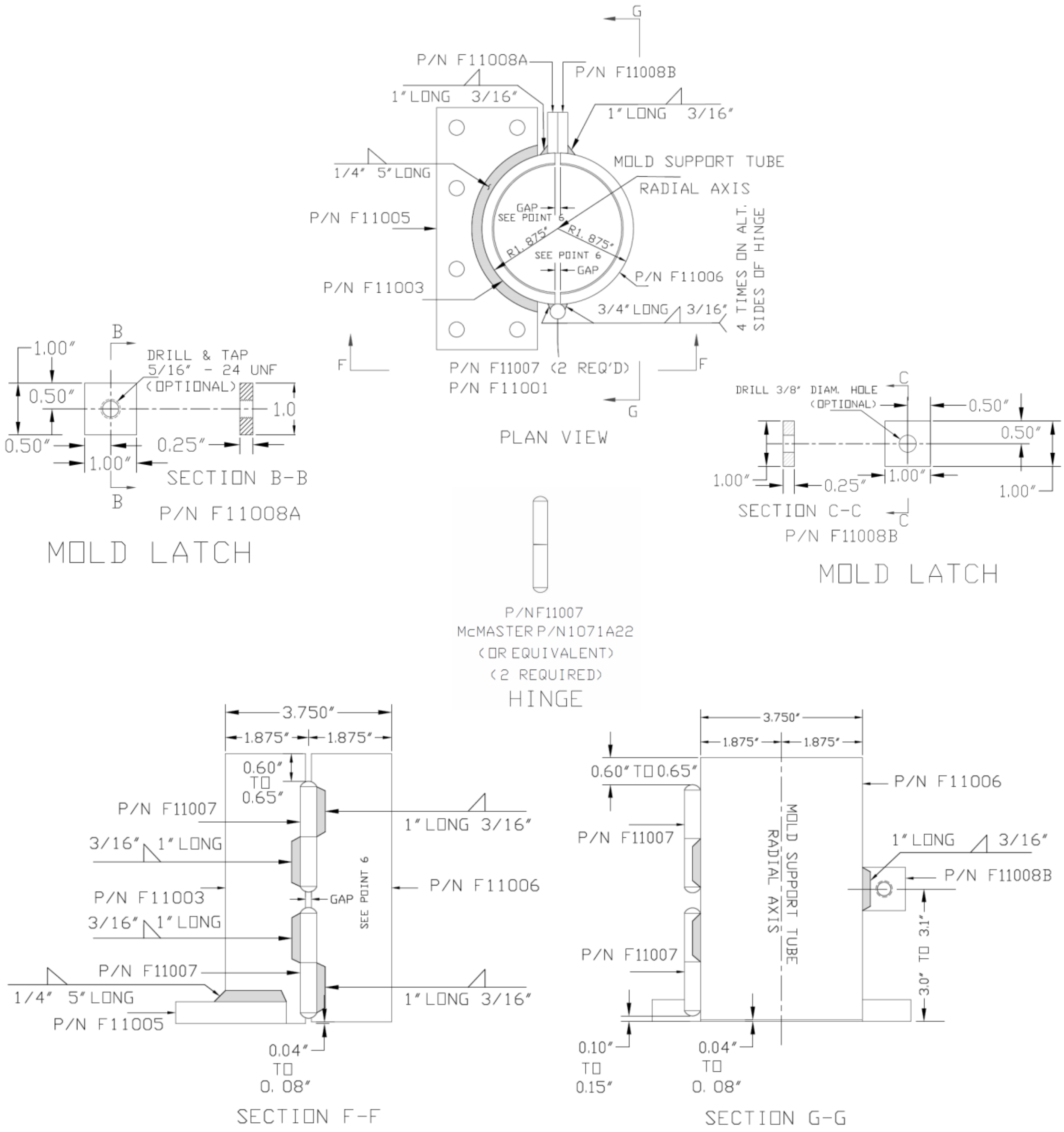

Figure A1.4 –3x6 PM Device Mold Support Assembly

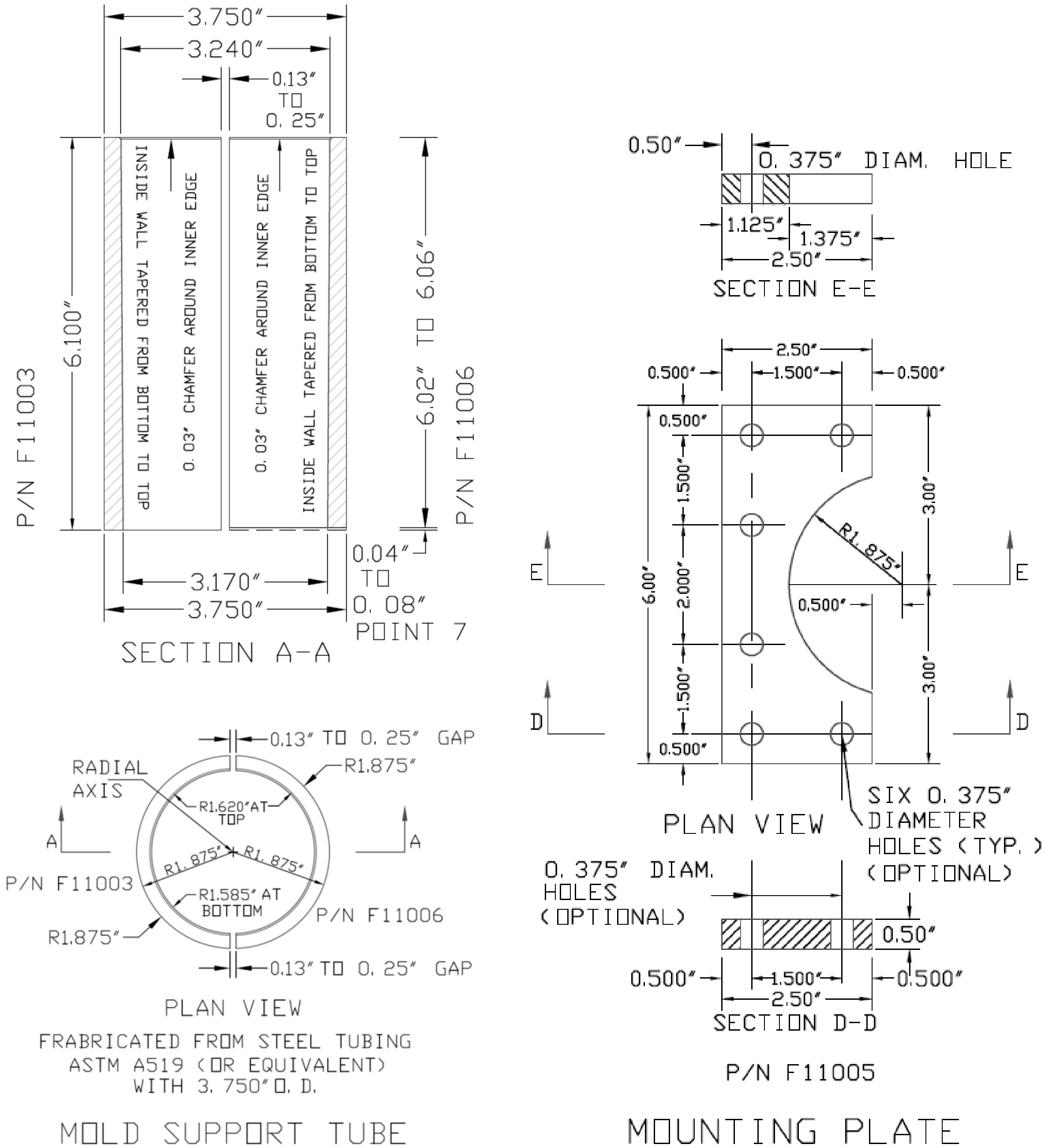

Figure A1.5 –3x6 PM Device Mold Support Tube and Mounting Plate

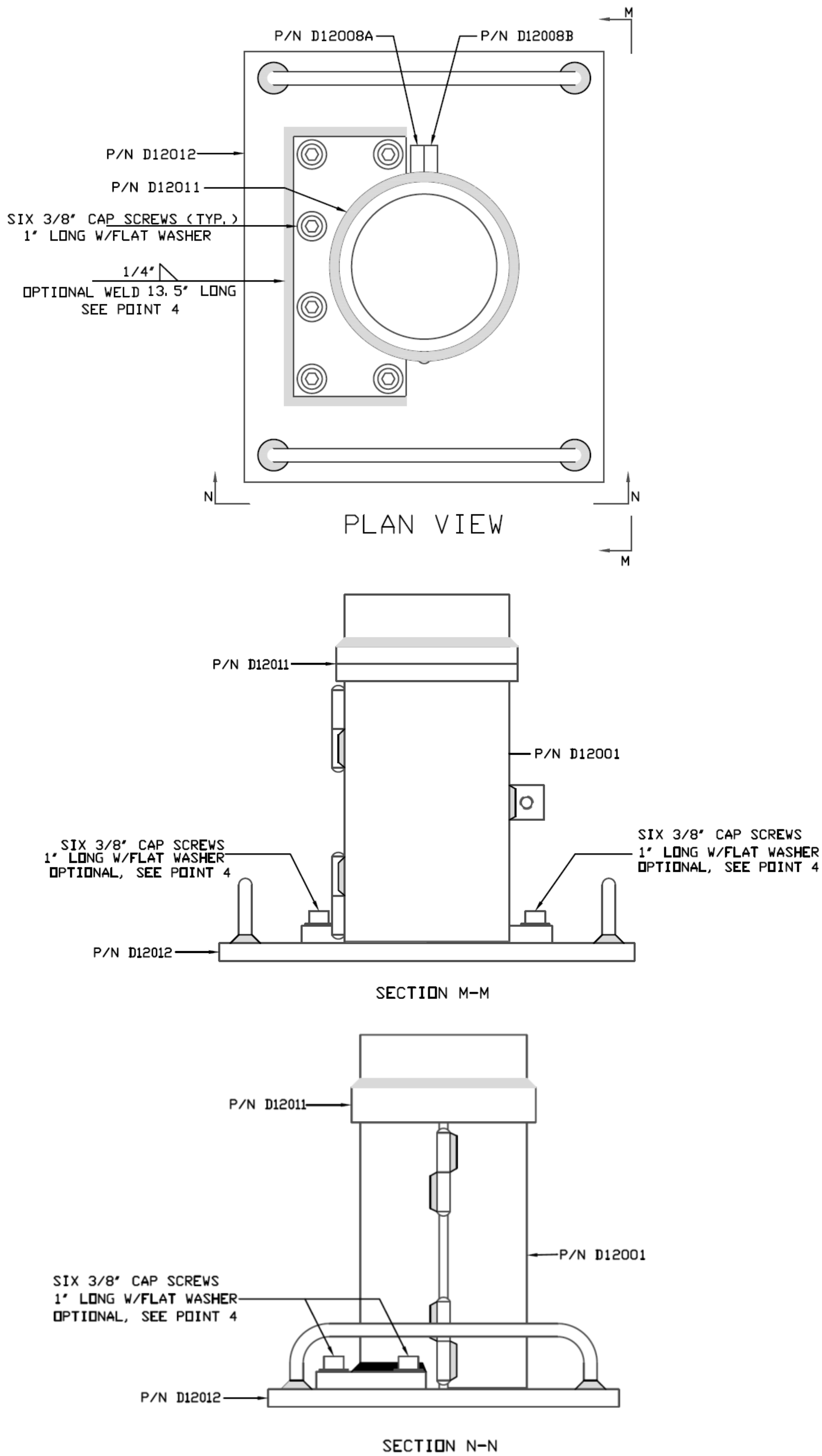

Figure A1.6 – Overall Views of 4x8 PM Device

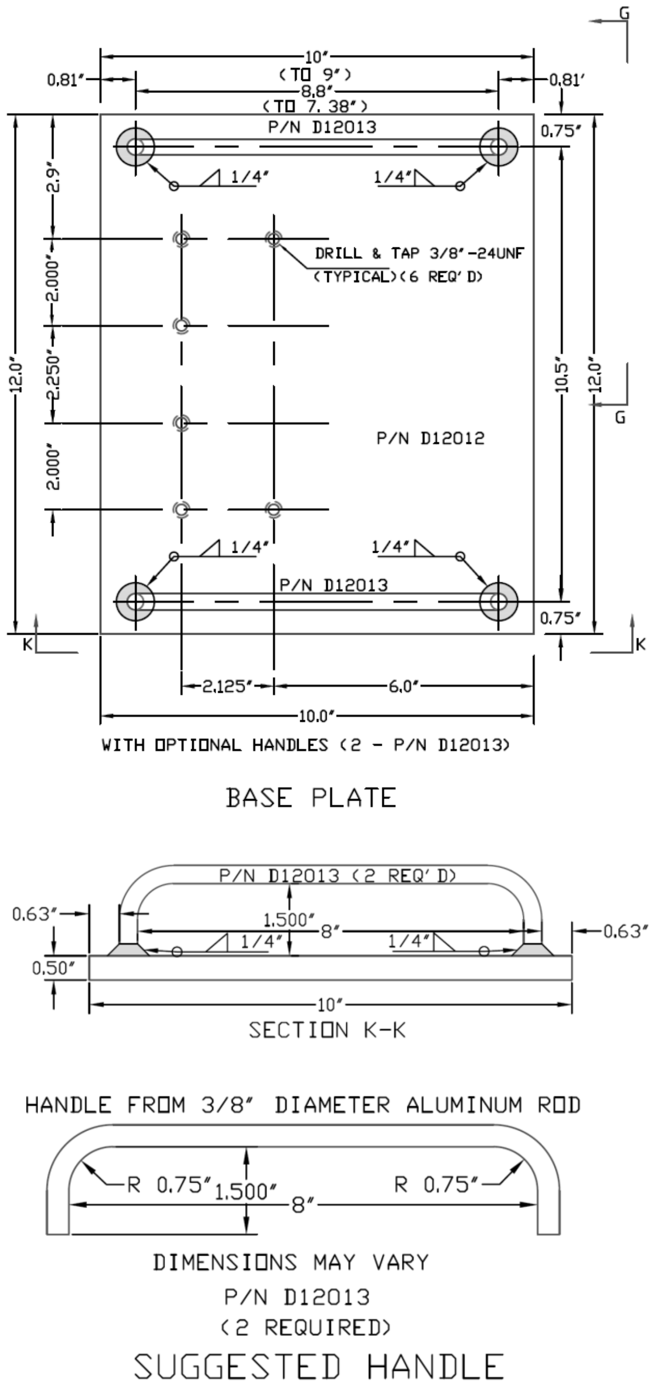

Figure A1.7 – 4x8 PM Device Base Plate

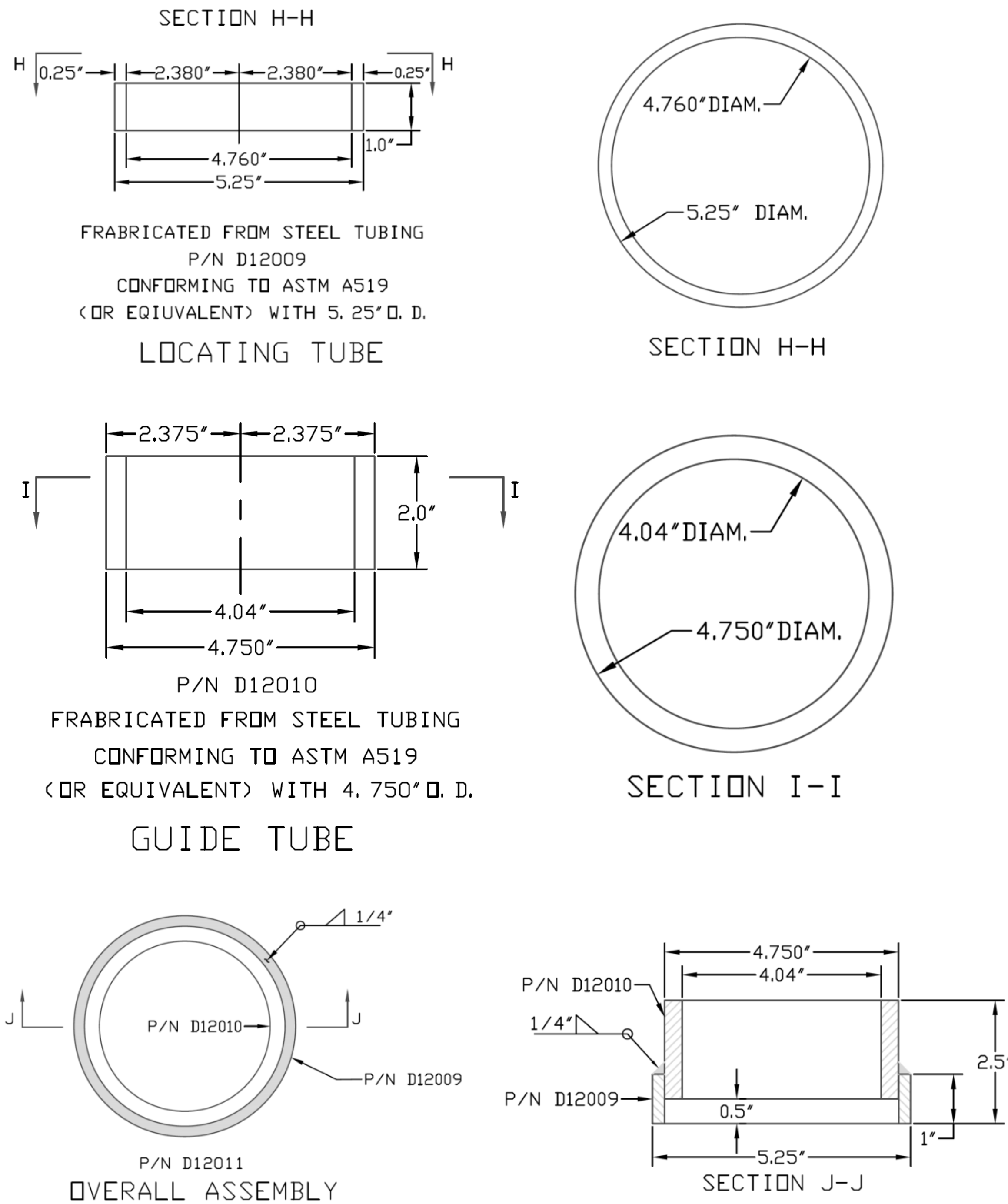

Figure A1.8 – 4x8 PM Device Collar

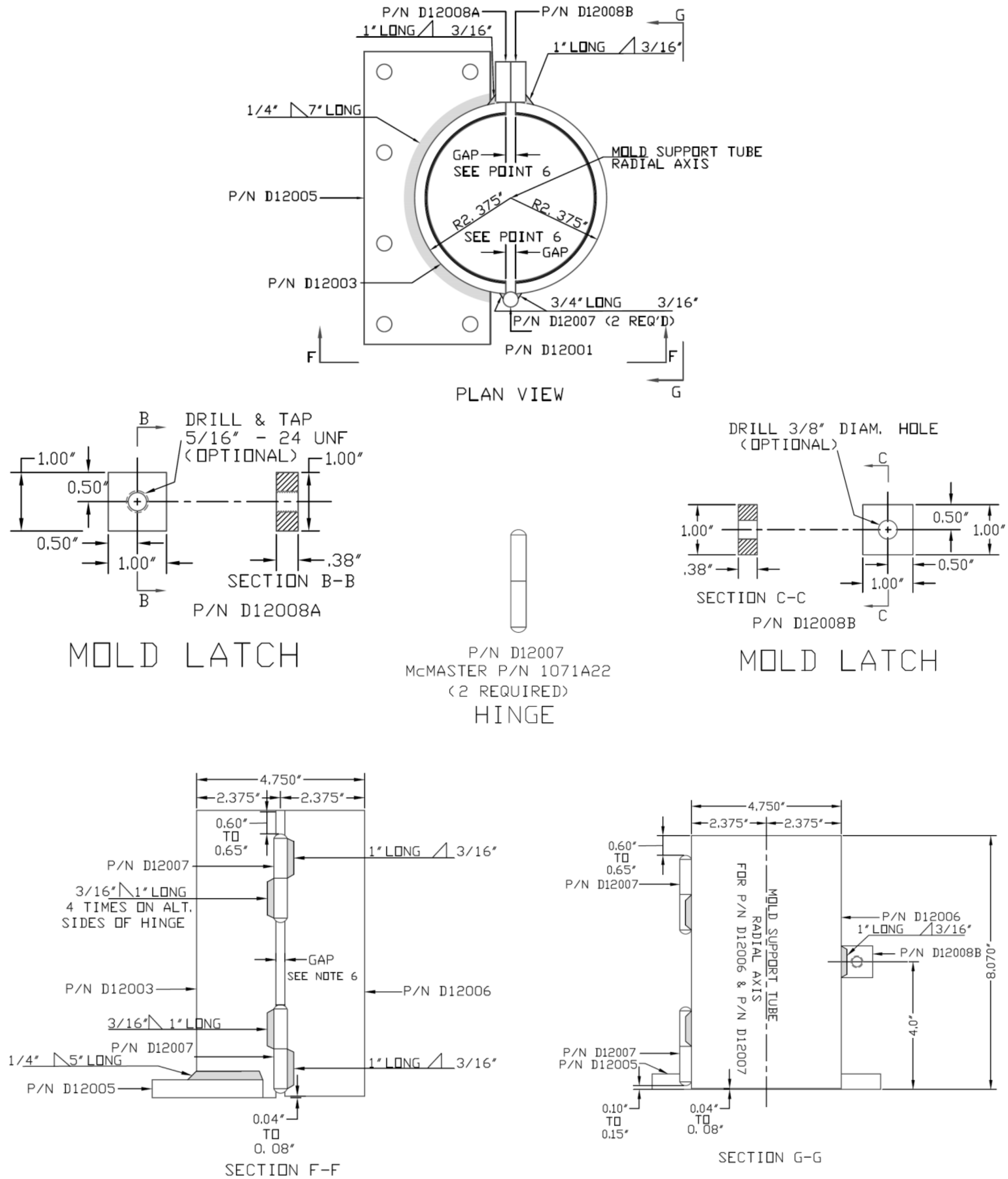

Figure A1.9 – 4x8 PM Device Mold Support Assembly

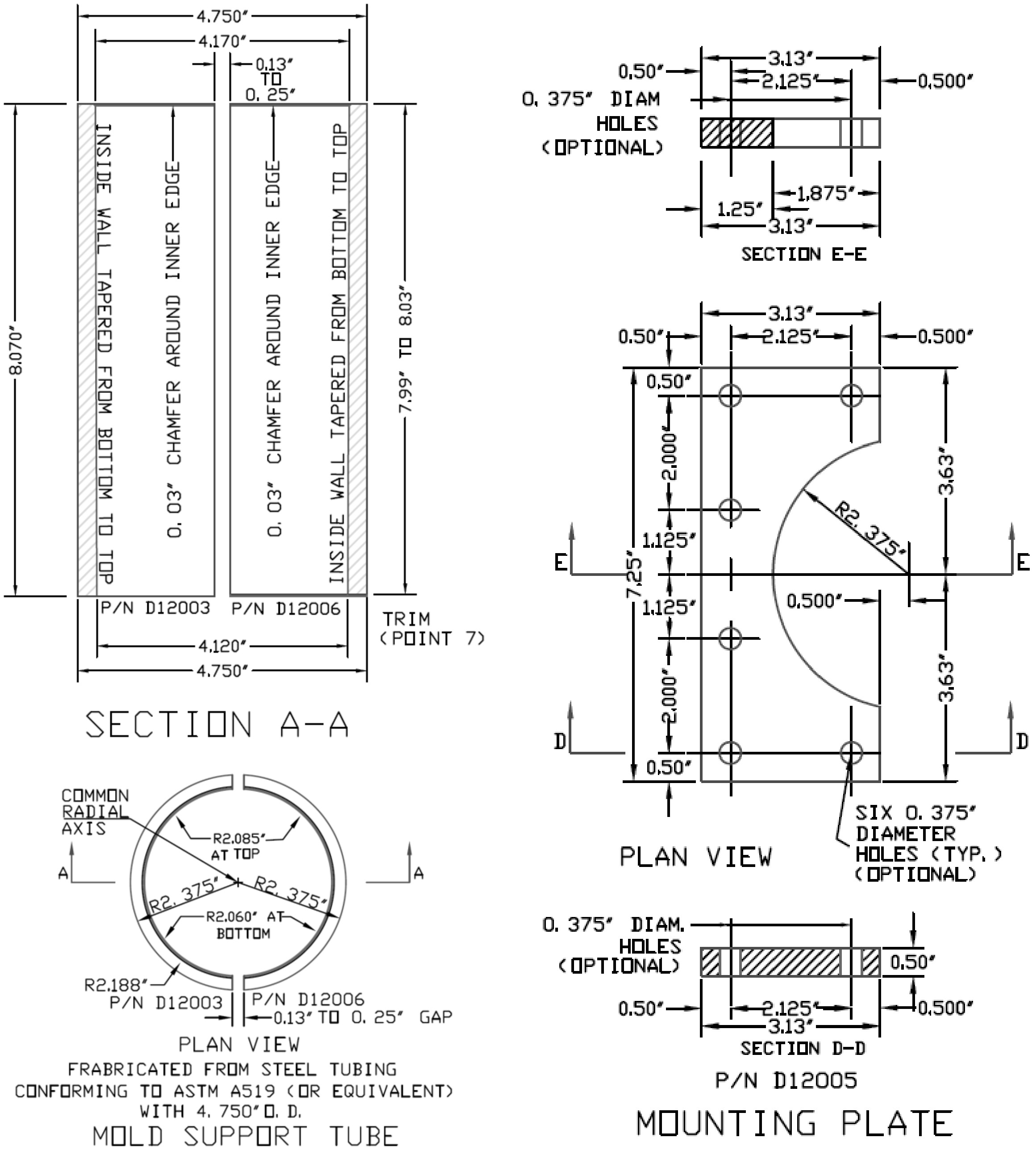

Figure A1.10 – 4x8 PM Device Mold Support Tube and Mounting Plate

APPENDIXES

X1. EXPECTED VARIABILITY IN SPECIMEN DIMENSIONS

X1.1. *Purpose*—This appendix presents commentary and data to expound upon expected variability in specimen dimensions when utilizing the PM Device.

X1.2. *Commentary*—Recommended practice for measuring the volume of specimens after extraction from the plastic mold assembly includes taking two diameter measurements 90 degrees apart within the top quarter inch and bottom quarter inch of the specimen and taking four height measurements evenly spaced along the circumference of the specimen. Any two diameter measurements should not deviate by more than two percent from each other. The representative height and diameter are the average of each of the 4 respective measurements.

X1.2.1. Based on 752 specimens compacted within a 3x6 PM Device (note varying compaction equipment was used), the representative specimen diameter ranged between 75.8-mm and 77.2-mm, and the standard deviation was 0.3-mm. For any individual specimen all four diameter measurements were within a 2% tolerance. Representative specimen heights ranged between 149.6-mm and 151.6-mm. Sullivan et al. (2015) provides specific data set information and additional guidance[1].

[1]Sullivan, W.G., Howard, I.L., Anderson, B.K. (2015). "Development of Equipment for Compacting Soil-Cement into Plastic Molds for Design and Quality Control Purposes," *Transportation Research Record: Journal of the Transportation Research Board*, 2511, pp. 102-111.

X2. METHOD FOR DETERMINING NUMBER OF BLOWS PER LAYER

X2.1. *Purpose*—Different materials exhibit different compaction characteristics; therefore, one material may require more or less hammer blows per layer to achieve the same target density as another material. This appendix presents a procedure to determine the number of hammer blows per layer to achieve a desired level of specimen density. This procedure can be used with either laboratory or field mixed materials.

X2.2. *Procedure*—First, determine which PM Device size will be utilized and use appropriate procedures outlined in Method A or Method B of this standard practice to fabricate specimens. Select multiple levels of compaction effort (e.g. 5, 7, 9 blows per layer). Fabricate a specimen or specimens at each compaction level and determine specimen dry density and the percentage of the target density achieved. Plot blow counts per layer against the determined percentage of target density and draw a trend line through the data points. Using the trend line select the number of blows per layer that will achieve the desired percentage of target density.

X2.3. *Example Procedure*—Figures X2.4a and X2.4b show an example of how to select the number of hammer blows per layer to achieve a desired 98% of maximum dry density as determined by T 134. Each plotted point represents an average of several specimens. In Figure X2.4a, an A2-4 soil-cement material was evaluated using the 3x6 PM Device and 4x8 PM Device, and the resulting needed blows per layer to achieve 98% of target density was 5 and 9, respectively. In Figure X2.4b, a much coarser material (85% in-place recycled asphalt pavement and 15% Steel Slag) was evaluated, and the needed blows per layer to achieve 98% of target density was 10.

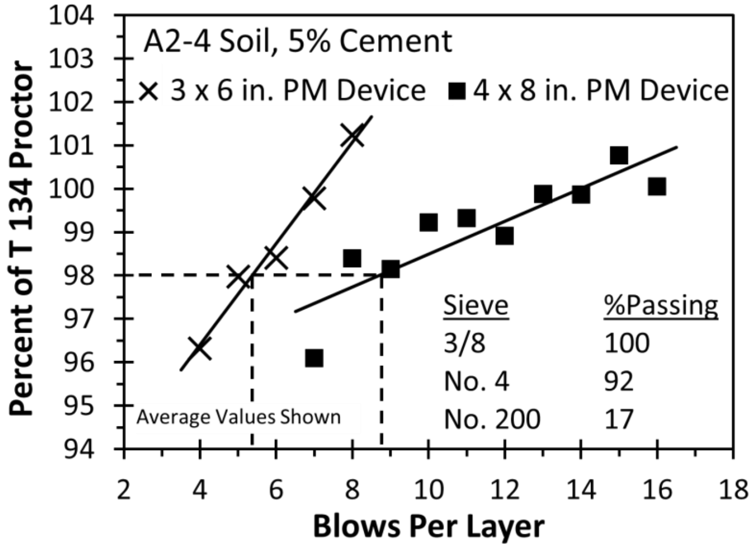

Figure X2.4a—Blow Count versus Percent of Target Density – Fine Material

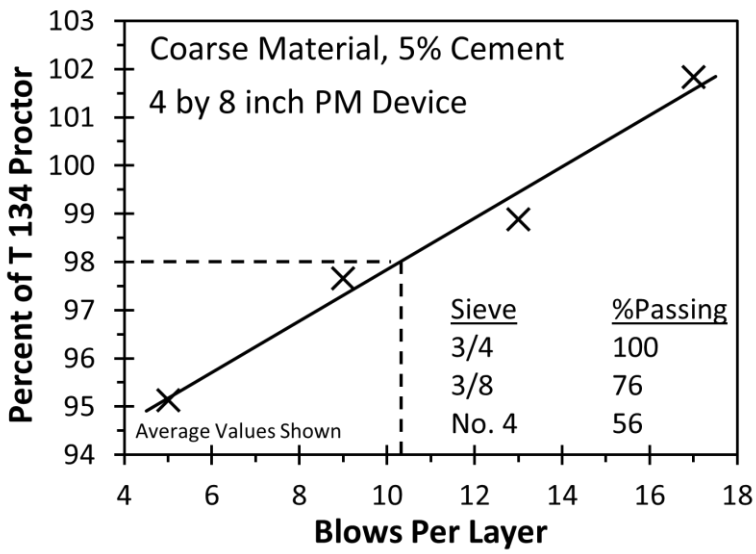

Figure X2.4b—Blow Count versus Percent of Target Density – Coarse Material