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AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428

Standard Test Method for Individual Piles Under Static Axial Tensile Load[1]

This standard is issued under the fixed designation D 3689; 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

This test method covers routine procedures to determine uplift capacity of piles. The provisions permit the introduction of more detailed requirements and procedures, when required to satisfy the objectives of the test program. While the procedures herein produce a relationship between applied load and pile movement, the results may not represent long-term performance.

1. Scope

1.1 This test method covers procedures for testing vertical or batter piles, individually or in groups, to determine response of the pile or pile group to a static tensile load applied axially to the pile or pile group. This test method is applicable to all deep foundation units that function in a manner similar to piles, regardless of their method of installation. This test method is divided into the following sections:

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1.2 This test method only describes procedures for testing single piles or pile groups. It does not cover the interpretation or analysis of the test results or the application of the test results to foundation design. See Appendix X1 for comments regarding some of the factors influencing the interpretation of test results. A qualified geotechnical engineer should interpret the test results for predicting pile performance and capacity. The term" failure", as used in this test method, indicates a rapid progressive movement of the pile or pile group in the direction of loading under a constant or decreasing load.

1.3 Apparatus and procedures designated "optional" are to be required only when included in the project specifications and, if not specified, may be used only with the approval of the engineer responsible for the foundation design. The word "shall" indicates a mandatory provision and "should" indicates a recommended or advisory provision. Imperative sentences indicate mandatory provisions. Notes and illustrations included herein are explanatory or advisory.

1.4 Wherever in this test method the term pile is used with reference to the test pile, it shall include test pile groups.

1.5 The values stated in inch-pound units are to be regarded as the standard.

1.6 *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.* For specific precautionary statements, see Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1143 Test Method for Piles Under Static Axial Compressive Load[2]

D 3966 Test Method for Piles Under Lateral Loads[2]

2.2 *ANSI Standard:*

B30.1 Safety Code for Jacks[3]

3. Significance and Use

3.1 The actual load capacity of a pile-soil system can best be determined by testing. Testing measures the response of a pile-soil system to loads and may provide data for research and development, engineering design, quality assurance, or acceptance or rejection in accordance with the specifications and contract documents.

3.2 Testing as covered herein, when combined with an acceptance criterion, is suitable for assurance of pile foundation design and installation under building codes, standards, and other regulatory statutes.

4. Apparatus for Applying Loads

4.1 *General*:

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.11 on Deep Foundations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

4.1.1 The apparatus for applying known tensile loads to the test pile shall be as described in 4.3, 4.4, 4.5, or 4.6 and shall be constructed so that the loads are applied axially minimizing eccentric loading. The method in 4.3 is recommended. The method in 4.5 should not be used for ultimatetests or for tests where large upward movements are anticipated. The method in 4.5 can be used to develop high tensile loads with relatively low jacking capacity. See 1.3 for use of the method in 4.6.

NOTE 1—When a pile group is subject to vertical test loads, cap rotations and horizontal displacements may occur. The occurrence of such horizontal movements, and the necessary reactions to resist such movements if they are to be prohibited, should be considered when designing and constructing the load apparatus for the group test.

NOTE 2—If it is not feasible to apply axial test loads to a batter pile, the results of a test on a similar nearby vertical pile generally may be used to evaluate the uplift capacity of the batter pile.

4.1.2 Where feasible, the immediate area of the test pile or pile group shall be excavated to the proposed pile cut-off elevation. The test pile(s) shall be cut off or built up to the proper grade as necessary to permit construction of the load-application apparatus, placement of the necessary testing and instrumentation equipment, and observations of the instrumentation.

4.1.3 Reaction piles, if used, shall be of sufficient number and installed so as to provide adequate reactive capacity. When testing a batter pile, reaction piles shall be battered in the same direction and angle as the test pile; the test beam(s) shall be perpendicular to the direction of batter. If two or more reaction piles are used at each end of the test beam(s), they shall be capped with a suitable steel beam(s) set on steel bearing plates or directly on and welded to steel reaction piles (Fig. 1, Fig. 2, and Fig. 3). Cribbing, if used as a reaction, shall be of sufficient plan dimensions to transfer the reaction loads to the soil without settling at a rate that would prevent maintaining the applied loads.

4.1.4 The clear distance between the test pile and the reaction pile(s) or cribbing shall be at least five times the butt diameter or diagonal dimension of the test pile, but not less than 8 ft (2.5 m).

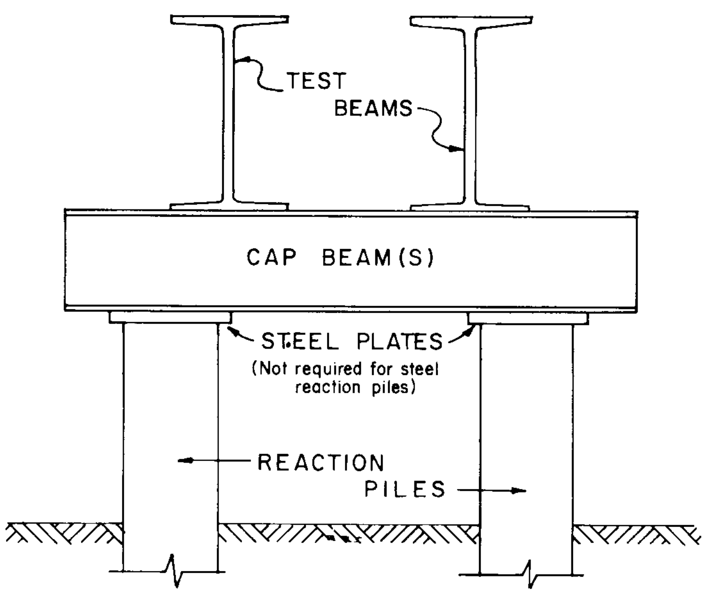
NOTE 3—The reactions should be far enough away from the test pile so that there is not significant effect on the performance of the test pile due to external loading. Factors such as type and depth of reaction, soil conditions, and magnitude of loads should be considered. When testing large diameter drilled shafts or caissons, the practicality of a spacing of five times the butt diameter or diagonal dimension should be considered and the standard modified as warranted.

4.1.5 Steel bearing plates of appropriate thickness for the loads involved shall be used above and below the hydraulic jack ram(s) and load cell(s), except if full bearing is provided on steel reaction piles, and between cap beam(s) and the tops of concrete or timber reaction piles. The size of the bearing plates shall be not less than the area covered by the base(s) of the hydraulic ram(s) or load cell(s) nor less than the total width of the test beam(s), cap beam(s), reaction piles, or any steel reaction member(s) so as to provide full bearing and distribution of the load. Bearing plates supporting the hydraulic jack ram(s) on timber cribbing shall have an area not less than five times the base area of the ram(s). Bearing plates that support test beam(s) on timber cribbing shall have a side dimension not less than 1 ft (0.3 m) greater than the total flange width of the test beam or overall width of double test beams.

4.1.6 Bearing plates, hydraulic jack ram(s), and load cell(s) shall be centered on test beam(s), cap beam(s), reaction member(s), reactions piles, or cribbing. Bearing plates shall be set perpendicular to the longitudinal axis of the pile. Plates shall be set in high-strength, quick-setting grout for concrete reaction piles, or welded to steel reaction piles, or, in the case of timber reaction piles, set on the pile top which shall be sawed off on a plane perpendicular to the longitudinal axis of the pile. Bearing plates on cribbing shall be set in a horizontal plane.

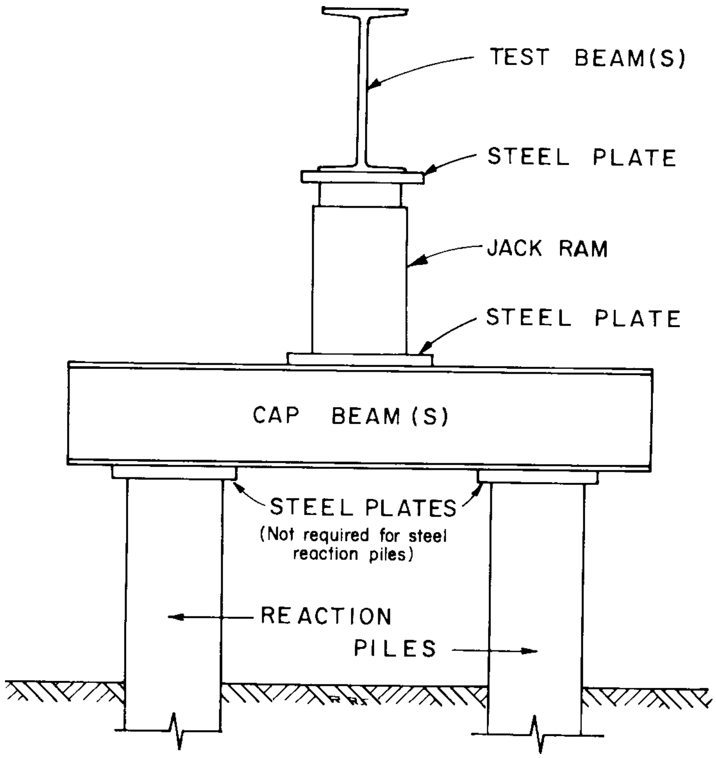
4.2 *Testing Equipment*:

4.2.1 *Hydraulic jacks*, including their operation, shall conform to ANSI B30.1.



NOTE 1—Use stiffener plates between flanges of all beams where structurally required.

FIG. 1 Typical Arrangement Where Two or More Reaction Piles are Used at End of Test Beam Using Set-Up Shown in Fig. 4

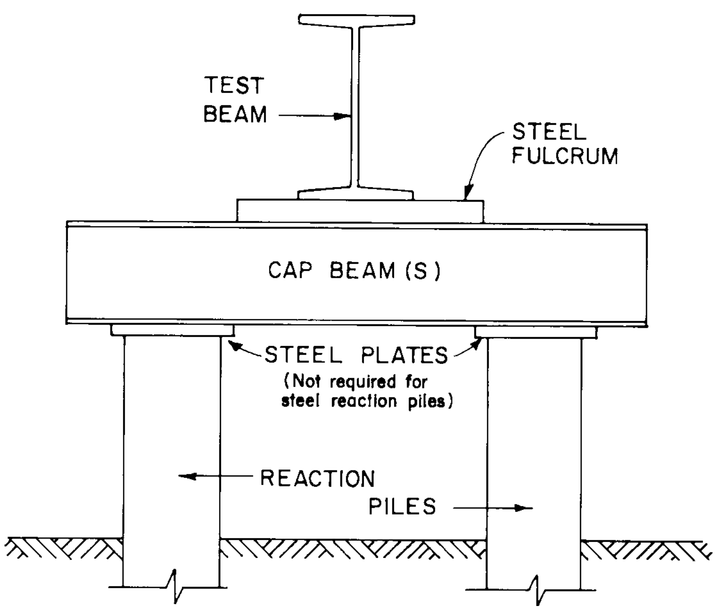


NOTE 1—Use stiffener plates between flanges of all beams where structurally required.

FIG. 2 Typical Arrangement Where Two or More Reaction Piles are Used at End of Test Beam Using Set-Up Shown in Fig. 5 or Fig. 6

4.2.2 Unless a calibrated load cell(s) is used, the complete jacking system including the hydraulic jack(s), hydraulic pump, and pressure gage shall be calibrated as a unit before each test or series of tests in a test program to an accuracy of not less than 5 % of the applied load. The hydraulic jack(s) shall be calibrated over its complete range of ram travel for increasing and decreasing applied loads. If two or more jacks are to be used to apply the test load, they shall be of the same ram diameter, connected to a common manifold and pressure gage, and operated by a single hydraulic pump.

4.2.3 When an accuracy greater than that obtainable withthe jacking system is required, a properly constructed load cell(s) or equivalent device(s) shall be used in series with the hydraulic jack(s). Load cell(s) or equivalent device(s) shall be



NOTE 1—Use stiffener plates between flanges of all beams where structurally required.

FIG. 3 Typical Arrangement Where Two or More Reaction Piles are Used at End of Test Beam Using Set-Up Shown in Fig. 6

calibrated prior to the test to an accuracy of not less than 2 % of the applied load and shall be equipped with a spherical bearing(s). Calibration of load cells shall include eccentric loading of 1:100 with an off-center of 1 in. (25 mm). After calibration, load cells shall not be subjected to impact loads.

4.2.4 Calibration reports shall be furnished for all testing equipment for which calibration is required, and shall show the temperature at which the calibration was done.

NOTE 4—Unless the hydraulic jack pump is attended at all times, it is recommended that the jacking system be equipped with an automatic regulator to hold the load constant as pile movement occurs.

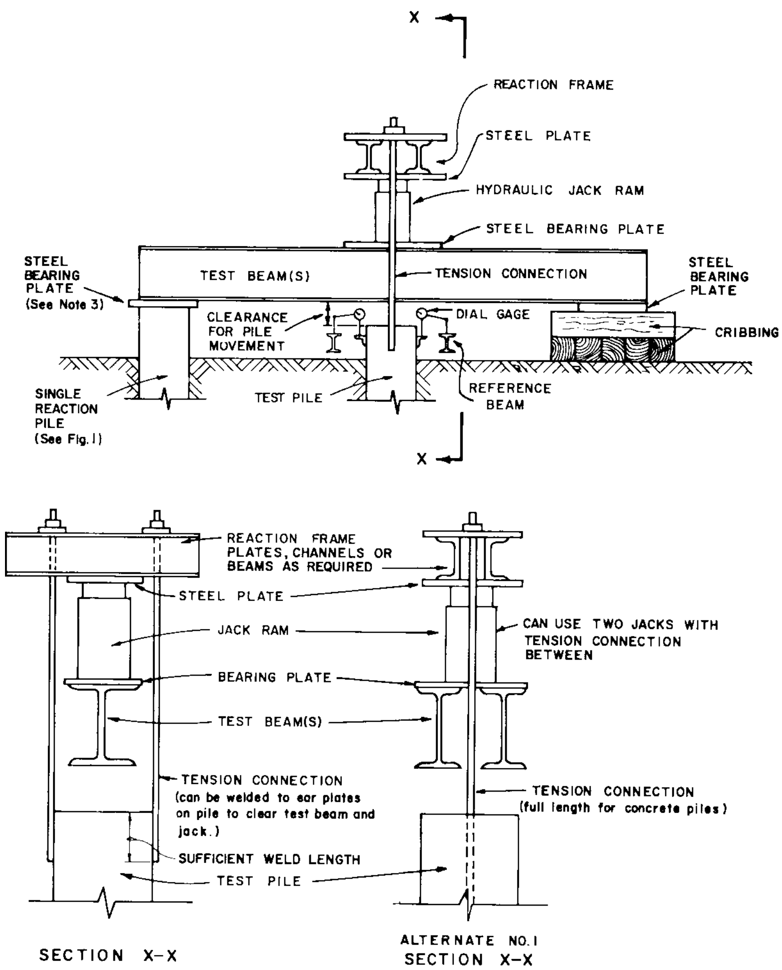
NOTE 5—Considerations should be given to employing a dual load-measuring system (pressure gage and load cell) to provide as a check and as a backup in case one system malfunctions. Hydraulic jack rams should have sufficient travel to provide for anticipated pile movements deflections of the test beam and elongation of connections to the test pile. The use of a single high-capacity jack is preferred to the use of multiple jacks. If a multiple jacking system is used, each jack should be fitted with a calibrated pressure gage (in addition to the master gage) in order to detect malfunctions and imbalances.

4.3 *Load Applied to Pile by Hydraulic Jack(s) Acting Between Supported Test Beam(s) and a Reaction Frame Anchored to the Pile* (Fig. 4):

4.3.1 Center over the test pile a test beam(s) of sufficient size and strength to avoid excessive deflection under load with adequate space between the bottom flange(s) of the test beam(s) (including any projecting parts of the connection system to the reaction frame) and the top of the test pile to provide for the total anticipated upward movement of the test pile under test. Support the ends of the test beam(s) with reaction piles or cribbing. If two or more reaction piles are used at each end of the test beam(s), they shall be capped with a suitable steel beam(s) set on the piles or on bearing plates (Fig. 1).

4.3.2 Center over the test pile and on the test beam(s) a hydraulic jack ram(s) (and load cell(s), if used) of sufficient capacity for the required load. Center a reaction frame over the jack ram(s) (or load cell(s), if used).

4.3.3 Anchor the reaction frame to the test pile by means of straps or bars welded to the pile or by bars or cables embedded in the pile. Tension connections between test pile and reaction



NOTE 1—Load on pile equals applied load.
NOTE 2—Use same type reaction (piles or cribbing) at both ends of test beam.
NOTE 3—Plate not required for steel reaction pile.
NOTE 4—Use stiffener plates between flanges of all beams where structurally required.

FIG. 4 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jack Acting Between Test Beam and Reaction Frame Anchored to Pile

frame shall be constructed so as to prevent slippage, rupture, or excessive elongation of the connection under the maximum required test load.

4.4 *Load Applied to Pile by Hydraulic Jacks Acting at Both Ends of Test Beam(s) Anchored to the Pile* (Fig. 5)—Center over the test pile a test beam(s) of sufficient size and strength to avoid excessive deflection under load. Anchor the test beam(s) to the test pile by means of steel straps, bars, cables, or other devices so that the connection between test pile and test beam(s) will resist the maximum required test load without slippage, rupture, or excessive elongation. Support each end of the test beam(s) on a hydraulic jack ram(s) (and load cell(s), if used) with the jack ram(s) supported on reaction pile(s) or cribbing.

4.5 *Load Applied to Pile By Hydraulic Jack(s) Acting at One End of Test Beam(s) Anchored to the Pile* (Fig. 6)—Center over the test pile a test beam(s) of sufficient size and strength to avoid excessive deflection under load. Anchor the test beam(s) to the test pile by means of steel straps, bars, cables, or other devices so that the connection between test pile and test beam(s) will resist the maximum required test load without slippage, rupture, or excessive elongation. Support one of the test beam(s) on a hydraulic jack ram(s) (and load cell(s), if used) with the jack ram(s) supported on a reaction pile(s) or cribbing. Support the other end of the test beam(s) on a steel fulcrum or similar device placed on a steel plate supported on a reaction pile(s) or cribbing.

4.6 *Load Applied to Pile by Hydraulic Jack(s) Acting Against Top of A-Frame or Tripod* (Fig. 7) (Optional):

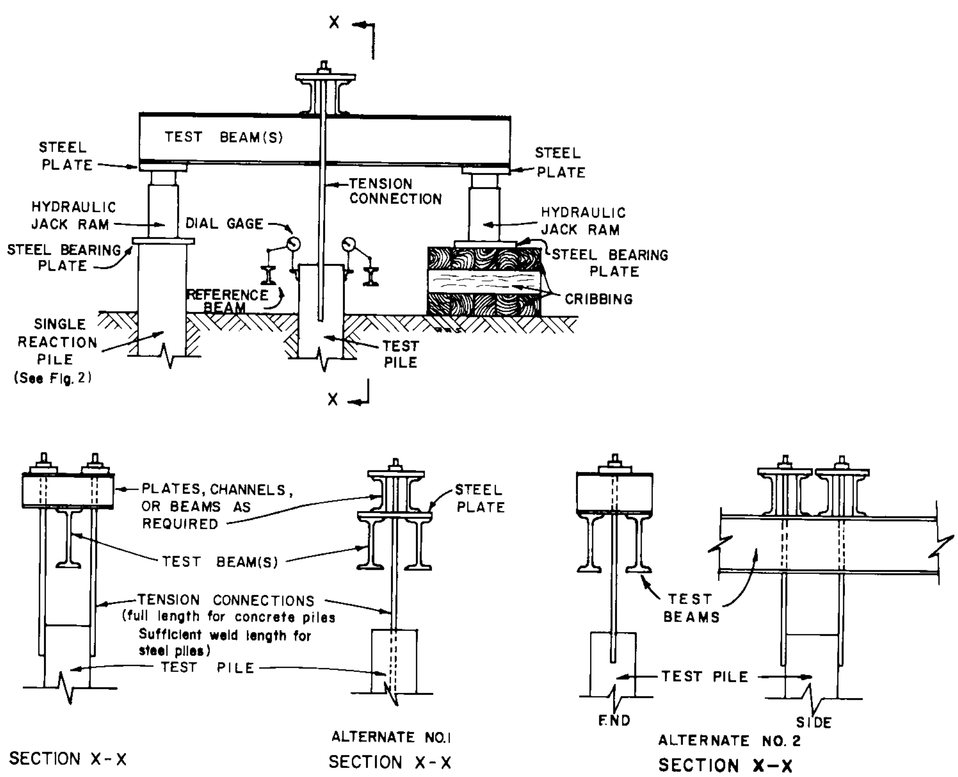
4.6.1 Center over the test pile an A-frame or tripod of sufficient size and strength to avoid excessive deflection under load. Support the A-frame or tripod on concrete footings, cribbing, or reaction piles. Tie together the bottoms of the A-frame or tripod legs or their supports, with tension members of sufficient strength to prevent spreading of the legs under load. If an A-frame is used, secure the top against lateral movement with not less than four guy cables anchored firmly to the ground.

4.6.2 Center over the test pile and on top of the A-frame or tripod a hydraulic ram(s) of sufficient capacity for the required load. If a center-hole jack ram is not used, center a reaction frame over the jack ram(s) and anchor the reaction frame to the test pile with tension straps or bars welded to the test pile or with bars or cables embedded in the test pile. If a center-hole jack ram is used, attach the tension bar passing through the ram to the center of the test pile. Tension connections between test pile and reaction frame or center-hole ram shall be constructed so as to prevent slippage, rupture, or excessive elongation of the connection under the maximum required test load.

5. Apparatus for Measuring Movements

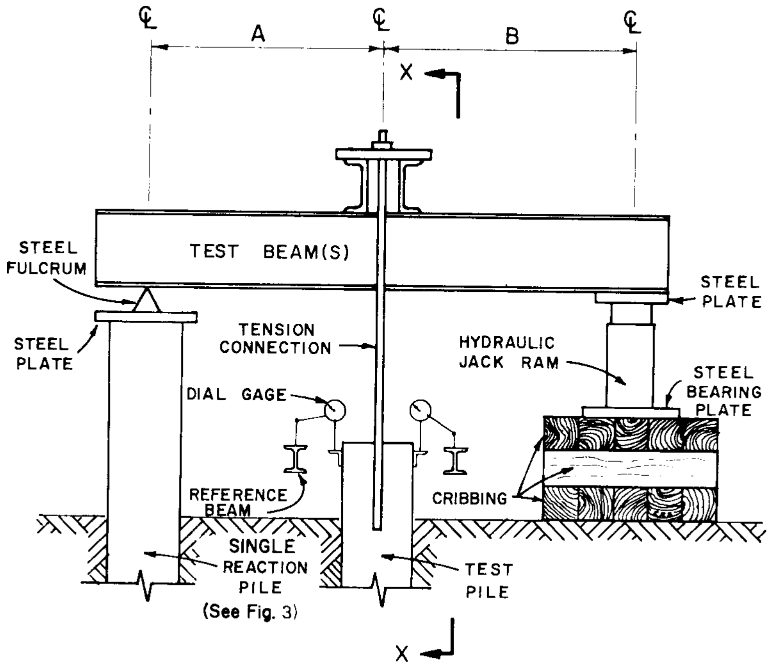
5.1 *General*:

5.1.1 All reference beams and wires shall be independently supported, with supports firmly embedded in the ground and at a clear distance of not less than 8 ft (2.5 m) from the test pile and from the reaction piles or cribbing. Reference beams shall be of sufficient stiffness to support the instrumentation so that excessive variations in readings do not occur. If steel reference



NOTE 1—Use same type reaction (piles or cribbing) at both ends of test beam.
NOTE 2—Load on pile is twice the jacking load unless the pressure gage has been calibrated for the two-jack system.
NOTE 3—Use stiffener plates between flanges of all beams where structurally required.

FIG. 5 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jacks Acting at Ends of Test Beam Anchored to Pile



NOTE 1—Load on pile × *A* = jacking load × (*A* + *B*).
NOTE 2—Use same type reaction (piles or cribbing) at both ends of test beam.
NOTE 3—Not recommended for ultimate tests.
NOTE 4—For section X-X, see Fig. 5.
NOTE 5—Use stiffener plates between flanges of all beams where structurally required.

FIG. 6 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jack Acting at One End of Test Beam Anchored to Pile

beams are used, one end of the beams shall be free to move horizontally as the length of beams change with temperature variations. Reference beams should be cross-connected if necessary for rigidity.

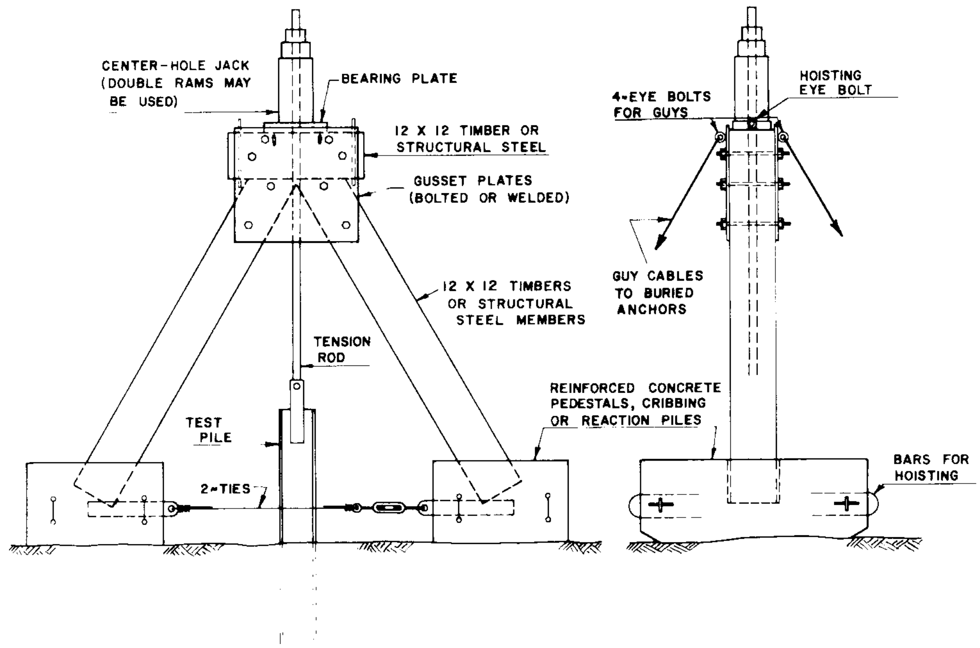
NOTE 6—The use of sufficiently stiff reference beams is recommended to avoid the necessity of cross connecting. If the beams must be cross connected, extra precautions must be taken to avoid accidental disturbance of the reference system since both beams would be affected.

5.1.2 Dial gages shall have at least a 3-in. (75-mm) travel or sufficient gage blocks shall be provided to allow this travel with shorter gage stems. The gages should read to 0.001 in. (0.025 mm). Smooth-bearing surfaces perpendicular to the direction of gage-stem travel shall be provided for the gage stems. Scales used to measure pile movements shall read to 1⁄64 or 0.01 in. (0.25 mm). Target rods shall read to 0.001 ft (0.3 mm).

5.1.3 All dial gages, scales, and reference points shall be clearly marked with a reference number or letter to assist in recording data accurately. Provisions shall be made to protect the instrumentation measuring system and reference system from adverse temperature variations and from disturbance. All gages, scales, or reference points shall be mounted so as to prevent movement relative to the test pile during the test.

5.2 *Pile Butt Movements*—The apparatus for measuring axial movement of the test pile butt shall consist of a primary and secondary system in accordance with the following methods. The method in 5.2.3 shall be used as a check system for all tests except those on batter piles. The method in 5.2.1 is recommended for the primary measuring system for all tests and shall be used for tests on batter piles. The requirements of 5.2.1 and 5.2.2 shall apply to both the primary and secondary systems except that for the secondary system only one dial gage or one wire-mirror-scale shall be required.

NOTE 7—Two separate measuring systems are required in order to provide a check on the observed data, to accommodate accidental disturbance of the measuring system, and to permit continuity of data in



NOTE 1—The A-frame may be guyed at various angles for testing batter piles or for special directional pull test.

FIG. 7 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jack(s) Acting at Top of A-Frame

case it becomes necessary to reset the gages or scales.

5.2.1 *Dial Gages*—Two reference beams, one on each side of the test pile, shall be oriented perpendicular to the direction of the test beam(s). At least two dial gages shall be mounted on the reference beams approximately equidistant from the center of and on opposite sides of the test pile with stems parallel to the longitudinal axis of the pile(s) and bearing on lugs firmly attached to the sides of the pile or pile cap. Alternatively, the two dial gages shall be mounted on opposite sides of the test pile with stems parallel to the longitudinal axis of the pile(s) and bearing on lugs firmly attached to the reference beams. However, gages may be mounted to bear on the top of the pile cap. For tests on individual batter piles, the dial gages shall be mounted along a line perpendicular to the direction of batter.

NOTE 8—The use of four dial gages mounted 90° apart is recommended to compensate for lateral movement or rotation of the pile butt due to accidental eccentric loading.

NOTE 9—For tests on batter piles, it is recommended that a dial gage be mounted in line with the direction of batter through the center of the test pile with the gage stem perpendicular to the longitudinal axis of the pile and bearing against a lubricated glass plate to measure lateral movements.

5.2.2 *Wire, Mirror, and Scale*—Two wires, one on each side of the test pile, shall be oriented perpendicular to the test beam(s) and shall be approximately perpendicular to the longitudinal axis of the test pile. Each wire shall pass across and be clear of the face of a scale that is mounted parallel to the axis of the test pile and that is attached to a mirror fixed to the test pile or pile cap so that consistent readings of axial movement can be made directly from the scale by lining up the wire and its image in the mirror. The wire shall be not more than 1 in. (25 mm) from the face of the scale. A suitable method shall be used to maintain tension in the wires throughout the test so that when plucked or tapped, the wire will return to its original position. Piano wire or equivalent type shall be used.

5.2.3 *Surveyor's Level or Laser Beam*—Readings using a surveyor's level or laser shall be taken on a target rod or a scale and shall be reference to a permanent bench mark located outside of the immediate test area or, alternatively, the surveyor's level or laser shall be mounted on an object of fixed elevation (for example a driven pile) outside of the immediate test area. Reference points or scales used in taking settlement readings shall be mounted on the sides of the test pile or pile cap and located on opposite sides except that reference points may be on top of the pile cap, or readings may be taken on a single fixed point in the center of the test pile top or pile cap (see Fig. 7).

5.2.4 *Other Types of Measuring Apparatus* (Optional)—Any other type of measuring device such as electric or optical gages of proven reliability and that yield an accuracy of 0.01 in. (0.25 mm) may be used.

5.3 *Lateral Movements* (Optional)—The lateral movements of the top of the test pile or pile group shall be measuring to an accuracy of 0.1 in. (2.5 mm) using either of the following methods: (*a*) two dial gages mounted on the reference beam 90° apart with their stems perpendicular to the longitudinal axis of the test pile(s) and bearing against the sides of the test pile or plate mounted on the side of the pile or pile cap, or (*b*) an engineer's transit reading from fixed positions scales mounted horizontally on the sides of the test pile or pile cap 90° apart with readings referenced to fixed foresights or backsights. For tests on batter piles, one of the gages or scales shall be oriented in the direction of the batter.

5.4 *Incremental Strain Measurements* (Optional):

5.4.1 The test pile(s) shall be instrumented as specified to determine distribution of load transfer from the pile to the soil. If strain rods or telltales are used, they shall be installed in or on the test pile terminating at the pile tip and at other points along the pile as required, and shall be sheathed or encased to ensure free movement of the rods during the test. The influence of the sheathing on the elastic properties of the pile section shall be considered. If electric resistance strain gages are used, the gage type and installation shall be as specified and shall include temperature compensation gages.

5.4.2 Pile butt axial movements shall be measured with dial gages (see 5.2.1). The movements of the top of each strain rod relative to the top of the test pile shall be measured with a dial gage reading to 0.001 in. (0.02 mm). Dial gages shall be referenced to points near the top of the test pile.

6. Safety Precautions

6.1 All operations in connection with pile load testing shall be carried out in such a manner so as to minimize, avoid, or eliminate the exposure of people to hazards. Following are examples of safety rules that should be followed in addition to general safety requirements applicable to construction operations. All applicable codes and regulations will apply.

6.1.1 All work areas, walkways, platforms, etc., shall be kept clear of scrap, debris, small tools, accumulations of snow and ice, mud, grease, oil, or other slippery substances.

6.1.2 All timbers, and blocking and cribbing material, shall be in good serviceable condition with flat surfaces and without rounded edges.

6.1.3 Jacks shall conform to the requirements of ANSI B30.1. Jacks shall be equipped with spherical bearing plates or shall be in complete and firm contact with the bearing surfaces and shall be aligned so as to avoid eccentric loading.

6.1.4 Loads shall not be hoisted, swung, or suspended over anyone and shall be controlled by tag lines.

6.1.5 The attachment of the test pile to the test beam or reaction frame shall be designed and installed to transmit the required loads with an adequate factor of safety.

6.1.6 For tests on batter piles, all inclined jacks, bearing plates, test frame members, etc., shall be firmly fixed in place or adequately blocked so as to prevent slippage upon release of load.

6.1.7 Only authorized personnel shall be permitted within the immediate test area.

7. Loading Procedures

7.1 *General*—Apply tensile test loads with a hydraulic jack(s) in line with the central longitudinal axis of the pile.

NOTE 10—Before testing piles driven into cohesive soils, sufficient time should elapse between driving and testing to allow dissipation of any excess pore water pressure that may have resulted from pile driving and to permit the regain of the soil strength (known as soil freeze or soil set-up). The length of the waiting period will depend on such things as the amount of excess pore water pressure built up, the degree of soil structure disturbance resulting from pile driving, and the soil properties. It could range from a minimum of 3 to 30 days or longer, and the actual required waiting period may be determined by testing or prior experience.

7.2 *Standard Loading Procedure*—Unless failure occurs first, load the pile to 200 % of the anticipated pile design load for tests on individual piles or to 150 % of the group design load for tests on pile groups, applying the load in increments of 25 % of the individual pile or group design load. Maintain each load increment until the rate of movement is not greater than 0.01 in./h ((0.25 mm)/h) but not longer than 2 h. Provided that the test pile has not failed, remove the total test load anytime after 12 h if the butt movement over a 1-h period is not greater than 0.01 in. (0.25 mm); otherwise allow the total load to remain on the pile for 24 h. After the required hold time, remove the test load in decrements of 25 % of the total test load with 1 h between decrements. If pile failure occurs continue jacking the pile until the movement equals 15 % of the largest butt diameter or diagonal dimension of the pile(s) tested.

NOTE 11—Testing a pile to failure provides valuable information to the design engineer and is recommended for pile tests performed prior to the foundation design or to evaluate comparative performances of different type piles. Such testing assists in the selection of optimum pile type and design load.

NOTE 12—If the test pile(s) approaches or has approached incipient failure at the full test load, consideration may be given to decreasing the standard loading increments during the latter stages of the test or subsequent tests.

7.3 *Cyclic Loading* (Optional)—For the first application of test load increments, apply such increments in accordance with 7.2. After the application of loads equal to 50, 100, and 150 % of the pile design load for tests on individual piles, or 50 and 100 % of the group design load for tests on pile groups, maintain the total load in each case for 1 h and remove the applied load decrements equal to the loading increments, allowing 20 min between decrements. After removing each total applied load, reapply the load to each preceding load level in increments equal to 50 % of the design load, allowing 20 min between increments. Apply additional loads in accordance with 7.2. After the total required test load has been applied, hold and remove the test load in accordance with 7.2.

7.4 *Loading in Excess of 200 % of Pile Design Uplift Load* (Optional)—After the load has been applied and removed in accordance with 7.2, reload the test pile or pile group to the standard test load in increments of 50 % of the pile or pile group design load, allowing 20 min between load increments. Then, increase the load to the maximum specified, or to failure if it occurs first, following the standard loading procedures in 7.2. If failure does not occur, hold the full load in accordance with 7.2 and then remove the load in four equal decrements, allowing 1 h between decrements.

7.5 *Constant Time Interval Loading* (Optional)—Follow the procedures of 7.2 except apply load in increments of 20 % of the pile or group design load with 1 h between load increments and unload the pile with 1 h between load decrements.

7.6 *Constant Rate of Uplift Method* (Optional):

7.6.1 The apparatus for applying loads shall have a capacity as specified and the hydraulic jack ram(s) shall have a minimum travel of 25 % of the average test pile diameter or diagonal dimension, or 8 in. (200 mm), whichever is less. A mechanical pump equipped with a bleed valve, variable speed device, or other means of providing a smooth variable delivery shall be used.

7.6.2 Test the pile at an uplift rate within a range of 0.02 to 0.04 in./min (0.5 to 1.0 mm/min) or as otherwise specified. Vary the applied load as necessary to maintain the specified uplift rate. The rate of uplift may be controlled by checking the time taken for successive small equal increments of upward movement and adjusting the rate of jacking accordingly. Alternatively, any mechanical or electrical device may be used to control the uplift rate.

7.6.3 Continue loading the pile until no further increase in the load is necessary for continuous pile upward movement at the specified rate unless the capacity of the loading apparatus is reached. Hold the load required to achieve the specified uplift rate until the total pile withdrawal is at least 8 in. (200 mm) or 25 % of the average pile diameter or diagonal dimension, whichever is less, after which, release the load.

7.6.4 If a video recording system is used to record the test data, a digital clock reading to seconds shall be used and the clock and all gages shall be easily readable and located within the camera field.

7.7 *Quick Load Test Method for Individual Piles* (Optional):

7.7.1 The apparatus for applying the load shall have a capacity as specified and shall be in accordance with 4.3 or 4.4.

7.7.2 Apply the load in increments of 10 to 15 % of the proposed design load with a constant time interval between increments of 2½ min, or with smaller increments, or longer time intervals, or both, as otherwise specified. Add load increments until continuous jacking is required to maintain the test load or until the specified capacity of the loading apparatus is reached, whichever occurs first, at which time stop the jacking. After a 5-min interval or as otherwise specified, remove the full load from the pile.

NOTE 13—For 7.6 and 7.7, it is recommended that the full test load be removed in at least four approximately equal decrements with 5 min between decrements so the shape of the rebound curve may be determined.

8. Procedures for Measuring Pile Movements

8.1 *General*—For axial movements, take readings on the test pile or pile cap. For lateral movements, take readings on the sides of the test pile or pile cap. Take required readings at each properly identified gage, scale, or reference point as nearly simultaneously as practicable. Clearly indicate and explain any adjustments made to instrumentation or to data recorded in the field.

8.2 *Standard Measuring Procedures*—Take and record readings of time, load, and pile movement immediately before and after the application of each load increment or the removal of a load decrement. Take and record additional readings after each increase in load at the following intervals: 2, 4, 8, 15, 45, 60, 80, 100, and 120 min. During periods when the load is held constant for more than 2 h, take and record readings at 1-h intervals. During unloading, take and record readings at 30-min intervals between decreases in load. After reducing the load to zero, take and record readings after 1, 2, and 12 h.

NOTE 14—If incremental strain measurements as in 5.4 are made using strain gages, gage readings should be taken and recorded before and after the pile is installed and immediately before the application of test loads so that a complete strain history is obtained and residual stresses can be accounted for.

8.3 *Measurements for Constant Rate of Uplift Loading*—Take and record readings of load, time, and pile movement at least every 30 s or at sufficient intervals to determine the rate of uplift being achieved. If automatic monitoring and recording devices are used, they shall be operated continuously during each test. When the pile has achieved its specified rate of uplift, continue to take and record readings for the duration of loading and to determine the maximum load applied. During unloading, take and record readings of load, time, and pile recovery every 1 min. Take and record a final reading 1 h after all load has been removed.

8.4 *Readings for Quick Load Test Method*—Take readings of time, load, and movement, and record immediately before and after the application of each load increment and at intermediate time intervals as specified. When the maximum load has been applied, take readings and record when the jacking is stopped. Repeat readings after 2½ min and again at 5 min thereafter. If a longer holding period than in 7.7.2 is specified, take and record additional readings as specified. Take readings of time and rebound, and record after all load has been removed. Repeat readings after 2½ min and again at 5 min thereafter.

NOTE 15—Level readings should be taken on the reference beams and on the reaction system using a surveyor's level or transit and target rod or scale to determine if any excessive movement occurs. Such readings should be taken and recorded before any test load is applied, at the proposed design load, at the maximum test load, and after all the load has been removed. Intermediate readings may be required if results during testing appear unusual.

NOTE 16—When testing piles in granular soils in dewatered excavations which will be submerged during service, the groundwater level should be maintained as near to the existing ground surface as possible and the depth to the groundwater level should be measured and recorded during the test.

9. Report

9.1 The report of the load test shall include the following information when applicable:

9.1.1 *General*:

9.1.1.1 Project identification,

9.1.1.2 Project location,

9.1.1.3 Test site location,

9.1.1.4 Owner,

9.1.1.5 Structural engineer,

9.1.1.6 Geotechnical engineer,

9.1.1.7 Pile contractor,

9.1.1.8 Test boring contractor,

9.1.1.9 Designation and location of nearest test boring with reference to test pile,

9.1.1.10 Log of nearest test boring,

9.1.1.11 Horizontal control datum, and

9.1.1.12 Vertical control (elevation) datum.

9.1.2 *Pile Installation Equipment*:

9.1.2.1 Make, model, type and size of hammer,

9.1.2.2 Weight of hammer and ram,

9.1.2.3 Stroke of ram,

9.1.2.4 Rated energy of hammer,

9.1.2.5 Rated capacity of boiler or compressor,

9.1.2.6 Type and dimensions of capblock and pile cushion,

9.1.2.7 Weight and dimensions of drive cap and follower,

9.1.2.8 Size of predrilling or jetting equipment,

9.1.2.9 Weight of clamp, follower, adaptor, and oscillator for vibratory driver,

9.1.2.10 Type, size, length, and weight of mandrel,

9.1.2.11 Type, size, and length of auger,

9.1.2.12 Type and size of grout pump, and

9.1.2.13 Type, size, wall thickness, and length of drive casing.

9.1.3 *Test and Reaction Piles*:

9.1.3.1 Identification and location of test and reaction piles,

9.1.3.2 Design load of pile or pile group,

9.1.3.3 Type of pile(s)—test and reaction,

9.1.3.4 Test pile material including basic specifications,

9.1.3.5 Tip and butt dimensions of pile(s),

9.1.3.6 General quality of timber test piles including occurrence of knots, splits, checks and shakes, and straightness of piles,

9.1.3.7 Preservative treatment and conditioning process used for timber test piles including inspection certificates,

9.1.3.8 Wall thickness of pipe test pile,

9.1.3.9 Weight per foot of H test pile,

9.1.3.10 Description of test pile tip reinforcement or protection,

9.1.3.11 Description of banding—timber piles,

9.1.3.12 Description of special coating used,

9.1.3.13 Test pile (mandrel) weight as driven,

9.1.3.14 Date precast test piles made,

9.1.3.15 Concrete cylinder strengths when test pile driven and when pile tested (approximate),

9.1.3.16 Description of internal reinforcement used in test pile (size, length, number longitudinal bars, arrangement, spiral, or tie steel),

9.1.3.17 Condition of precast piles including spalled areas, cracks, head surface, and straightness of piles,

9.1.3.18 Effective prestress,

9.1.3.19 Which piles vertical or batter,

9.1.3.20 Degree of batter,

9.1.3.21 Length of test pile during driving,

9.1.3.22 Embedded length—test and reaction piles,

9.1.3.23 Tested length of test pile, and

9.1.3.24 Final elevation of test pile butt(s) referenced to fixed datum.

9.1.4 *Pile Installation—Test and Reaction*:

9.1.4.1 Date driven (installed),

9.1.4.2 Date concreted (cast-in-place),

9.1.4.3 Volume of concrete or grout placed in pile,

9.1.4.4 Grout pressure used,

9.1.4.5 Description of pre-excavation or jetting (depth, size, pressure, duration),

9.1.4.6 Operating pressure for double-acting and differential type hammers,

9.1.4.7 Throttle setting—diesel hammer (at final driving),

9.1.4.8 Fuel type—diesel hammer,

9.1.4.9 Description of special installation procedures used such as piles cased off,

9.1.4.10 Type and location of pile splices,

9.1.4.11 Driving logs (blows per foot),

9.1.4.12 Final penetration resistance (blows per inch),

9.1.4.13 Stroke or equivalent stroke of diesel hammer at final pile penetration,

9.1.4.14 When capblock replaced (indicate on log),

9.1.4.15 When pile cushion replaced (indicate on log),

9.1.4.16 Rate of pile penetration s/ft for last 10 ft (3 m) vibratory driving,

9.1.4.17 Horsepower delivered and frequency of vibratory driver during final 10 ft (3 m) of pile penetration,

9.1.4.18 Cause and duration of interruptions in pile installation, and

9.1.4.19 Notation of any unusual occurrences during installation.

9.1.5 *Pile Testing*:

9.1.5.1 Date tested,

9.1.5.2 Type test,

9.1.5.3 Number of piles in group test,

9.1.5.4 Sketch showing layout and spacing of piles in groups,

9.1.5.5 Brief description of load application apparatus, including jack capacity,

9.1.5.6 Description of instrumentation used to measure pile movement including location of gages or other reference points with respect to pile butt (see Note 17),

9.1.5.7 Description of special instrumentation such as strain rods or gages including location of such with reference to pile butt,

9.1.5.8 Special testing procedures used,

9.1.5.9 Tabulation of all time, load, and movement readings,

9.1.5.10 Identification and location sketch of all gages, scales, and reference points (see Note 17),

9.1.5.11 Description and explanation of adjustments made to instrumentation or field data, or both,

9.1.5.12 Notation of any unusual occurrences during testing,

9.1.5.13 Test jack and other required calibration reports,

9.1.5.14 Groundwater level (see Note 15), and

9.1.5.15 Temperature and weather conditions during tests.

NOTE 17—Photographs can be very helpful in showing the instrumentation set-up, locations of gages, scales, and reference points.

NOTE 18—In addition to the above required information to be reported, the results of any in-place and laboratory soil tests should be made available for the proper evaluation of test results.

10. Precision and Bias

10.1 *Precision*—It is not practicable to specify the precision of the procedure in this test method for measuring pile movement versus applied load because each pile is unique due to the variable nature of the ground in which it is embedded. Furthermore, retesting a particular pile commonly results in different data from the initial testing due to plastic movement of the ground in which the pile is embedded.

10.2 *Bias*—There is no true value for the data resulting from this test method for measuring pile movement versus applied load since each pile is unique due to the variable nature of the ground in which it is embedded. Therefore, no statement on bias is being made.

APPENDIX

(Nonmandatory Information)

X1. SOME FACTORS INFLUENCING INTERPRETATIONS OF TEST RESULTS

X1.1 Potential residual loads (strains) in the pile which could influence the interpreted distribution of load along the pile shaft.

X1.2 Possible interaction of friction loads from test pile with downward friction transferred to the soil from reaction piles obtaining part or all of their support in soil at levels above the tip level of the test pile.

X1.3 Changes in pore water pressure in the soil caused by pile driving, construction fill, and other construction operations which may influence the test results for frictional support in relatively impervious soils such as clay and silt.

X1.4 Differences between conditions at time of testing and after final construction such as changes in grade or groundwater level.

X1.5 Potential loss of soil resistance from events such as excavation, or scour, or both, of surrounding soil.

X1.6 Possible differences in the performance of a pile in a group or of a pile group from that of a single isolated pile.

X1.7 Affect on long-term pile performance of factors such as creep, environmental effects on pile material, friction loads from swelling soils, and strength losses.

X1.8 Type of structure to be supported, including sensitivity of structure to movement and relations between live and dead loads.

X1.9 Special testing procedures which may be required for the application of certain acceptance criteria or methods of interpretation.

X1.10 Requirement that all conditions for nontested piles be basically identical to those for test pile including such things as subsurface conditions, pile type, length, size and stiffness, and pile installation methods and equipment so that application or extrapolation of the test results to such other piles is valid.